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USING ROUTING PROTOCOLS FOR EFFICIENT OPERATION OF AD HOC NETWORKS

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***Abstract*: Due to the diversity of mobile ad hoc networks, its research interests have grown rapidly. MANETs use the traditional TCP/IP architecture to provide end-to-end communication between nodes. One of the interesting research areas in it is routing. Routing in MANETs is a complex task and has attracted enormous attention from researchers. This has led to the development of many different routing protocols for MANETs. It is quite difficult to determine which protocols can be best suited for different network scenarios, such as increasing node density and traffic. In this paper, we present a review and analysis of a wide range of routing protocols.**

***Index terms*: mobile ad hoc network, routing protocols, topology, packets.**

I. INTRODUCTION

The term mobile hosts is used to refer to any category of packet. To forward a packet to a mobile host, the network must first locate it. Each host also has a permanent home address that can be used to determine its location.

The limited resources of MANETs have made designing an efficient and reliable routing strategy a very challenging problem. An intelligent routing strategy is needed to efficiently utilize the limited resources while adapting to changing network conditions, such as network size, traffic density, and network partitions. In addition, the routing protocol may need to provide different levels of QoS for different types of applications and users.

When each node receives an updated packet, they update their network view and link state information using a shortest path algorithm to select the next hop node for each destination. In distance vector routing.

One of the important research areas of MANET is the creation and maintenance of ad hoc networks using routing protocols.

This paper discusses the analysis of various protocols and presents the possibilities of their use.

II. LITERATURE REVIEW AND PROBLEM STATEMENT

Nowadays, with the immense growth in wireless network applications like handheld computers, PDAs and cell phones, researchers are encouraged to improve the network services and performance. One of the challenging design issues in wireless Ad Hoc networks is supporting mobility in Mobile Ad Hoc Networks (MANETs).

According to Ammar Odeh, the mobility of nodes in MANETs increases the complexity of the routing protocols and the degree of connection's flexibility. However, the flexibility of allowing nodes to join, leave, and transfer data to the network pose security challenges [1].

Routing protocols define a set of rules which governs the journey of message packets from source to destination in a network. In MANET, there are different types of routing protocols each of them is applied according to the network circumstances [2].

The major requirements of a routing protocol were proposed by Zuraida Binti et al, that includes minimum route acquisition delay, quick routing reconfiguration, loop-free routing, distributed routing approach, minimum control overhead and scalability [3].

III. SCOPE OF WORK AND OBJECTIVES

To overcome the problems associated with the link-state and distance-vector algorithms a number of routing protocols have been proposed for MANETs. These protocols can be classified into three different groups: global/proactive, on demand/reactive and hybrid.

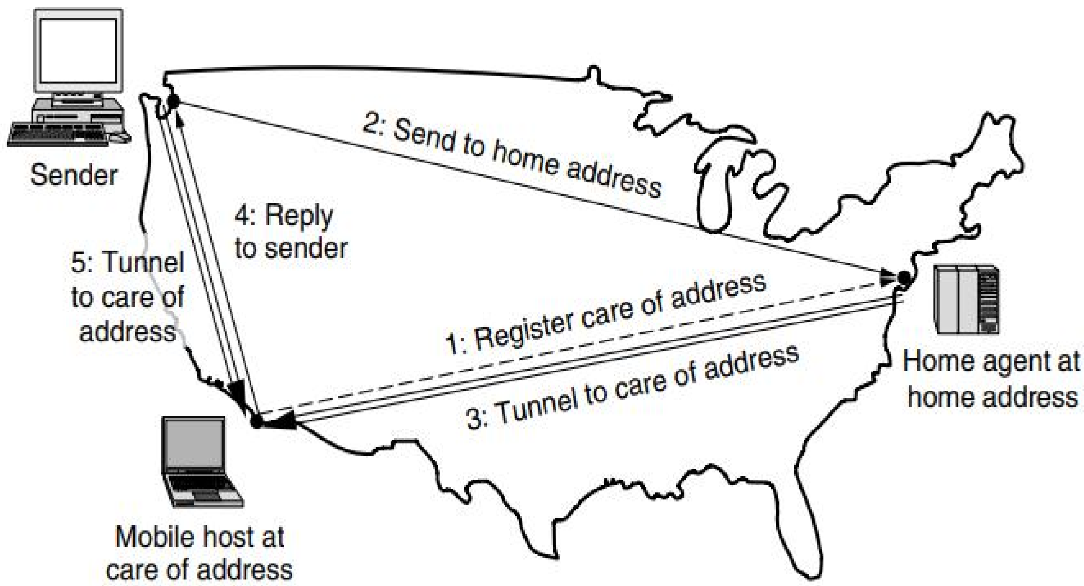
The aim of the paper is to demonstrate the capabilities of these protocols with a view to their use in the network.

IV. DIRECT PATHFINDING PROBLEM

There are many variations of mobile routing. The effectiveness of the protocols depends on the type of ad hoc networks that are useful in practice.

This scheme is modeled after IPv6 mobility, a form of mobility used on the Internet (fig. 1).

To ensure fast convergence, routes include a sequence number that is controlled by the destination. The destination sequence number is like a logical clock. The destination increments it each time it sends a new ROUTE REPLY. Senders request a new route by including the destination sequence number of the last route they used in the route request, which will be either the route sequence number that was just cleared or 0 as the initial value. The request is broadcast until a route with a higher sequence number is found.



Packet routing for mobile hosts

With the request protocol, intermediate nodes store only those routes that are in use. Other route information received during the broadcast is discarded after a short delay. Discovering and storing only used routes helps save bandwidth and battery power compared to standard distance vector protocols, which periodically broadcast updates.

If all nodes know their geographical positions, forwarding to the destination can proceed without calculating a route, simply by going in the right direction and turning back to avoid any dead ends.

Classification of current routing protocols. Several routing protocols have been proposed for MANETs. These protocols can be divided into three different groups: global/proactive, on-demand/reactive, and hybrid. In proactive routing protocols, routes to all destinations (or parts of the network) are determined at startup and maintained using a periodic route update process. In reactive protocols, routes are determined when they are needed by the source using a route discovery process. Hybrid routing protocols combine the main features of the first two classes of protocols into one.

Proactive Routing Protocols. In proactive routing protocols, each node maintains routing information for all other nodes in the network. The differences between these protocols lie in the way routing information is updated, the discovery of information stored in each routing table, and the type of information stored in each routing table. In addition, each routing protocol can maintain a different number of tables.

Destination-Sequential Distance Vector (DSDV). The DSDV algorithm [4] is a modification of DBF, that guarantees loop-free routes. It provides a single path to the destination, which is selected using a distance-vector shortest-path routing algorithm.

DSDV creates a large amount of overhead in the network due to the periodic update message requests, and this overhead grows in terms of OðN2Þ. Therefore, the protocol does not scale in a large network because a large portion of the network bandwidth is used in the update procedures.

Distance Effect Routing Algorithm for Mobility (DREAM). The DREAM routing protocol [5] uses a different routing approach than the routing protocols described so far. In DREAM, each node knows its geographic coordinates via GPS. In DREAM, the routing overhead is further reduced because the frequency of update messages is proportional to the mobility and distance effect. This means that stationary nodes do not need to send update messages.

Multimedia Support in Mobile Wireless Networks (MMWN). In the MMWN routing protocol [6], the network is maintained using a clustering hierarchy. Each cluster has two types of mobile nodes: switches and endpoints. Each cluster also has a Location Manager (LM), which manages the location of each cluster.

All information in the MMWN is stored in a dynamically distributed database. The advantage of the MMWN is that only the LMs perform location updates and location discovery. This means that the routing overhead is significantly reduced compared to traversal table-based algorithms (such as DSDV and WRP).

Reactive routing protocols. Routing protocols are designed to reduce the overhead of proactive protocols by maintaining only active route information.

In stepwise routing [7], each data packet contains only the destination address and the next hop address. Therefore, each intermediate node on the way to the destination uses its routing table to forward each data packet to its destination. The advantage of this strategy is that the routes are adaptable to the dynamically changing environment of MANETs, as each node can update its routing table as it receives new topology information and, accordingly, forward data packets on newer and better routes. Using new routes also means that fewer route recalculations are required during data transmission.

On-demand acyclic multipath routing (ROAM). The ROAM [8] routing protocol uses inter-node coordination along directed acyclic subgraphs that are derived from the distance of a router to a destination. This operation is referred to as "diffuse computation". The advantage of this protocol is that it eliminates the infinite search problem that exists in some on-demand routing protocols when a desired destination is no longer available. Also, each router maintains entries for the destinations that it routes data packets to (i.e., a router is a node that completes and/or connects a router to a destination).

This significantly reduces the amount of storage space and bandwidth required to maintain an up-to-date routing table. Another innovation of ROAM is that whenever a router's distance to a destination changes, it sends update messages to neighboring nodes. While this has the advantage of increasing network connectivity, in highly dynamic networks it can prevent nodes from going into sleep mode to save power.

Associativity-based routing (ABR). ABR [9] is another source-initiated routing protocol, which also uses a query-reply technique to determine routes to the required destinations.

However, in ABR route selection is primarily based on stability. To select stable route each node maintains an associativity tick with their neighbors, and the links with higher associativity tick are selected in preference to the once with lower associativity tick. However, although this may not lead to the shortest path to the destination, the routes tend to last longer. Therefore, fewer route reconstructions are needed, and more bandwidth will be available for data transmission.

Temporarily Ordered Routing Algorithm (TORA). The TORA routing protocol is based on the LMR protocol. It uses a similar procedure for link replacement and route repair as in LMR and the creation of DAGs [10]. The advantage of TORA is that it reduces the large-scale control messages to the set of neighboring nodes where the topology change occurred. Another advantage of TORA is that it also supports multicasting, although this is not integrated into its core operation. TORA can be used in conjunction with the Lightweight Adaptive Multicasting Algorithm (LAM) to provide multicasting.

Hybrid Routing Protocols. Hybrid routing protocols are a new generation of protocols that are both proactive and reactive in nature. These protocols are designed to increase scalability by allowing nearby nodes to work together and form a kind of backbone to reduce the cost of route discovery. This is mainly achieved by proactively maintaining routes to nearby nodes and determining routes to distant nodes using a route discovery strategy. Most of the hybrid protocols proposed to date are zone-based, meaning that the network is divided or perceived as a number of zones by each node.

Zone-based Hierarchical Link State (ZHLS). The ZHLS [11] routing protocol uses a hierarchical structure. In ZHLS, the network is divided into non-overlapping zones, and each node has a node ID and a zone ID, which are calculated using GPS. The hierarchical topology consists of two levels: node-level topology and zone-level topology.

Location management in ZHLS is simplified. This is because no cluster head or location manager is used to coordinate data transmission. This means that there is no processing overhead associated with selecting a cluster head or location manager compared to the HSR, MMWN, and CGSR protocols. This also means that single points of failure and traffic congestion can be avoided. Another advantage of ZHLS is that it reduces communication overhead.

Scalable Location Update Routing Protocol (SLURP). In SLURP [12], nodes are organized into non-overlapping zones. However, SLURP further reduces the cost of maintaining routing information by eliminating global route discovery. This is achieved by assigning a home region to each node in the network. The home region of each node is a single specific zone (or region) defined using a static mapping function, $f(NodeID) \rightarrow regionID$, where f is a many-to-one function that is static and known to all nodes.

An example of a function that can perform static zone mapping is $f(NodeID) = g(NodeID) mod K$, where $g(NodeID)$ is a random number generator that uses the node ID as a seed and returns a large number. Therefore, all nodes can determine each node's home region using this function, provided they have their own node ID.

Then, the intra-tree clustering algorithm is run to build the intra-zone routing table. This is followed by the execution of the cross-zone algorithm to establish connectivity with neighboring zones.

HARP uses the intra-zone and inter-zone routing tables created by DDR to establish a stable path between the source and destination. The advantage of DDR is that, unlike ZHLS, it does not rely on a static zone map to perform routing and does not require a root node or cluster head to coordinate data and control packet transmission between different nodes and zones.

V. RESULTS

This paper presents three categories of unicast routing protocols (some with multicast capability) (Table).

Global routing protocols, which are mostly derived from traditional link state or distance vector algorithms, proactively maintain network connectivity, while on-demand routing protocols determine routes as needed. Hybrid routing protocols use both reactive and proactive features, proactively maintaining intra-area information and reactively maintaining inter-area information.

Hybrid routing protocols have the potential to provide higher scalability than purely reactive or proactive protocols. This is because they attempt to minimize the number of forwarding nodes by defining a structure that allows nodes to work together to organize the routing performance. By working together, the best or most suitable nodes can be used to perform route discovery.

Comparing routing categories

Routing class	Proactive	Reactive	Hybrid
Routing structure	Both flat and hierarchical structures are available	Mostly flat, except CBRP	Mostly hierarchical
Availability of route	Always available	Determined when needed	Depends on the location of the destination
Control traffic volume	Usually high, attempt at reduction is made. E.g., OLSR, TBRPF	Lower than Global routing and further improved using GPS. E.g., LAR	Mostly, lower than proactive and reactive
Periodic updates	Yes, however some may use conditional. E.g., STAR	Not required. However, some nodes may require periodic beacons. E.g., ABR	Usually used inside each zone, or between gateways
Handling effects of mobility	Usually updates occur at fixed intervals. DREAM alters periodic updates based on mobility	ABR introduced LBQ. ROAM employs threshold updates. AODV uses local route discovery	Usually more than one path may be available. Single point of failures is reduced by working as a group
Storage requirements	High	Depends on the number of routes kept or required. Usually lower than proactive protocols	Usually depends on the size of each cluster or zone may be come as large as proactive protocols if clusters are big
Delay level	Small routes are predetermined	Higher than proactive	For local destinations small. Interzone may be as large as reactive protocols
Scalability level	Usually up to 100 nodes. O.LSR and TBRPF may scale higher	Source routing protocols up to few hundred nodes. Point-to point may scale higher. Also depends on the level of traffic and the levels of multihopping	Designed for up to 1000 or more nodes

This can potentially eliminate the need for overhead, as nodes know exactly where to look for a destination each time.

Another innovation of hybrid routing protocol is that they attempt to eliminate single points of failure and bottlenecks in the network. This is achieved by allowing any number of nodes to take over routing or data forwarding if the preferred path becomes unavailable.

VI. CONCLUSION

Considering the performance metrics and characteristics of all categories of routing protocols, several conclusions can be drawn for each category.

Implementing flat addresses in global routing may be straightforward, but it may not scale well for large networks [13]. To make the use of flat addresses more efficient, the amount of routing overhead introduced into networks must be reduced. One way to do this is to use a device such as GPS. For example, in the DREAM routing protocol, nodes exchange only location information (coordinates) and not full link state or distance vector information. Another way to reduce routing overhead is to use conditional updates instead of periodic updates.

However, the current problem with these schemes is location management, which also imposes significant overhead on the network. In demand routing protocols, flooding-based routing protocols such as DSR and AODV also have scalability problems. To increase scalability, route discovery and route maintenance must be controllable. This can be achieved by localizing the propagation of control messages to a specific region where the destination exists or where the connection is down.

Hybrid routing protocols can also work well in large networks. The advantage of this protocol over other hierarchical routing protocols is that they have simplified location management due to the use of GPS and do not use a cluster head to coordinate data transmission, which means that single points of failure and performance delays can be avoided. They are also easily adaptable to topology changes, as only the destination node and zone ID are required for routing.

VII. CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

VIII. DECLARATION ON GENERATIVE AI

During the preparation of this work, the author(s) used ChatGPT, Grammarly in order to: Grammar and spelling check, Paraphrase and reword. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the publication's content.

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