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Routing Protocols in FANET: Survey

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Abstract As a result of technological advances on electronic, computer and communication technology, it has been possible to produce UAV systems. These systems can fly autonomously and these are able to operate without any human personnel. In recent years, the capability and roles of Unmanned Aerial Vehicles have evolved and their usage in all around the world is been popular as a result of advancement in technology. The main focus is changing from use of one UAV to the use of more than one UAV so that they can perform well to achieve the desired goal. Networking models allow the nodes to communicate with each others to perform the operation. There are so many models and protocols which are used in FANET technology and each model has their own strength and weakness in terms of node mobility, connectivity, message routing, service quality etc. Here mainly used FANET protocols are discussed and open issues and challenges are also discussed

Keywords Network models, Protocol, VANET, FANET.

1 INTRODUCTION

There are many routing protocols in the wireless and ad-hoc environment and all of these protocols are not suitable for the FANET. Therefore to adopt the new networking model, some specific protocols have been implemented in literature and some of the previous ones are modified in the literature.

II. FANET NETWORKING MODELS

FANET protocols can be categorized in the four main classes;

- **Static protocols** have static routing tables there is no need to refresh these tables.
- **Proactive protocols**, also known as table driven protocols, are periodically refreshed
Routing tables.
- **Reactive protocols**, also called on-demand protocols, discover paths for messages on demand.
- **Hybrid protocols** use both proactive and reactive protocols

2.1 Static Routing Protocols

In static routing protocol, a routing table is computed and loaded to UAV nodes before a mission, and cannot be updated during the operation; therefore, it is static. In this type networking model, UAVs typically have a fixed topology. Each nodes can communicate with a few numbers of UAVs or ground stations, and it only stores their information. In case of a failure (of a UAV or ground station), for updating the tables, it is necessary to wait the end of the mission. Therefore, they are not fault tolerant and appropriate for dynamic environments.

Load Carry and Delivery Routing(LCDR)

is one of the first routing models in FANET.In this model, a UAV loads data from a ground node (or gets video image of its path); after that, it carries these valuable data to the destination by flying; and finally it delivers the data to a destination ground node (such as a military team or a ground control station), as depicted in fig.1

Multi-Level Hierarchical Routing :

Hierarchically organized UAV networks consist of a number of clusters to operate in different mission areas. Each cluster has a cluster head (CH), which represents the whole cluster, and it is possible to assign different functionalities

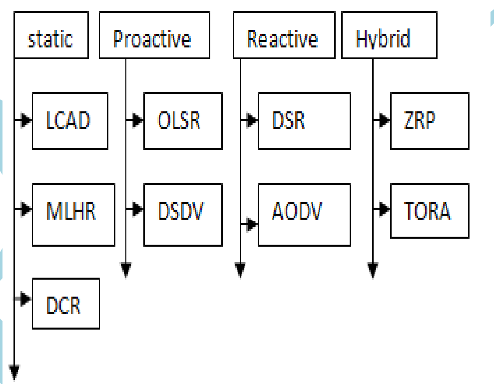

Fig.1 Routing Protocols in FANET

to each cluster. Each CH is in connection with the upper/lower layers (ground stations, UAVs, satellites, etc.) directly or indirectly.

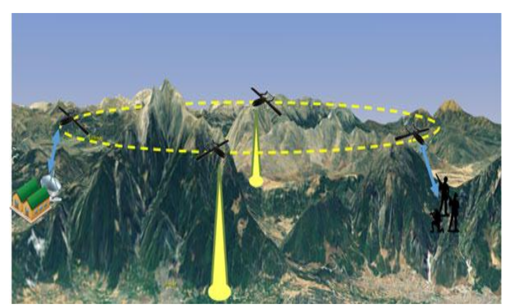

Fig .2 Load Carry and Delivery Routing

Data Centric Routing

Data-centric routing is a promising paradigm of routing mechanism and can be adapted for FANET. In this model, the consumer node (can be a ground node or a UAV) disseminates queries as subscription message in order to collect specific data from a specific area. The producer node decides which information to publish and starts data dissemination. When published data reach a UAV (as a relay node), it checks the subscription messages on it and forwards these data accordingly. Routing is done with respect to the content of data; and if needed, data aggregation algorithms can be used for energy-efficient data dissemination.

2.2 Proactive Routing Protocols

Proactive routing protocols (PRP) use tables to store all the routing information of each other's node or nodes of a specific region in the network. Various table-driven protocols can be usedin FANET, and they differ in the way of update mechanism of the routing table when the topology changes. The main advantage of proactive routing is that it contains the latest information of the routes; therefore, it is easy to select a path from the sender to the receiver, and there is no need to wait. However, there are some explicit disadvantages. Firstly, due to the need of a lot of message exchanges between nodes, PRPs cannot efficientlyuse bandwidth, which is a limited communication resource of FANET; therefore, PRPs are not suitable for highly mobile and/or larger networks. Secondly, it shows a slow reaction, when the topology is changed, or a failure is occurred. Two main protocols are widely used in VANETs: Optimized Link State Routing (OLSR) and Destination- Sequenced Distance Vector (DSDV) protocols.

Optimized Link State Routing

(OLSR) is a proactive link-state routing protocol, which uses two types of messages (hello and topology control messages) to discover neighbors.Hello messages are used for detecting neighbor nodes in the direct communication range. This message contains the list of known neighbors, and it is periodically broadcast to one-hop neighbors. On the other hand, topology control messages are used for maintaining topological information of the system. These messages are used periodically to refresh topology information; therefore, each node can re-calculate the routes to all nodes in the system. This periodic flooding nature of the protocol results a large amount of overhead. Therefore, to reduce this overhead Multi Point Relay (MPR) mechanism is used.

Destination Sequenced Distance Vector

(DSDV) is a table-driven proactive routing protocol. In DSDV, each node maintains a routing table (with sequence number) for all other nodes, not just for the neighbor nodes. Whenever the topology of the network changes , these changes are disseminated by the protocol update mechanism. The main advantage of DSDV are both the simplicity of algorithm and usage of the sequence numbers which guarantees the protocol to be loop free.

2.3 Reactive Routing Protocols

It is known as the on demand routing protocol which means if there is no any communication between the nodes then there is no need to store the route between the two.There are two different type of messages *Route Request* message and *Route Reply* message.Route request messages are produced by source node and route reply messages are produced by destination node.

Dynamic Source Routing (DSR) is a simple and effective RRP, which is designed mainly for multi-hops for wireless mesh networks. In DSR, the source node broadcasts a route request message to its neighbor nodes, which are in the wireless transmission range. In the whole communication process, there can be many route request messages. In DSR, each node can store multiple entries in its routing table for each destination. Another difference with DSR stems out from the fact that DSR data packets carry the complete path between source and the destination nodes. Therefore, to avoid confusion, the source node adds a unique request-id number to the produced message. DSR is a source demanding routing protocol and the source node stores the entire hop-by-hop route of the destination node. If the source node is unable to use its current route, due to changes in the network topology, then the route maintenance mechanism is activated. In such case, the source node has to use another route to the destination; if there is none, a new route discovery phase is started.

Ad-hoc On-demand Distance Vector (AODV) is a reactive protocol, which has same on-demand characteristics with DSR with different maintaining mechanisms of routing table. In AODV, each node stores a routing table, which contains a single record for each destination; In AODV, the source node (and also other relay nodes) stores the next-hop information corresponding to each data transmission.

2.4 Hybrid Routing Protocols

Hybrid routing protocol (HRP) is a combination of previous protocols, and is presented to overcome their shortcomings. By using HRP, the large latency of the initial route discovery process in reactive routing protocols can be decreased and the overhead of control messages in proactive routing protocols can be reduced.

Zone Routing Protocol (ZRP) is based on the concept of zones [37]. In this protocol, eachnode has a different zone, which is defined as the set of nodes .The routing inside the zone is called as intra-zone routing, and it uses proactive approach to maintain routes. If the source and destination nodes are in the same zone, the source node can start data transmission immediately. The inter-zone routing is responsible for sending data packets to outside of the zone. It uses reactive approach to maintain routes

Temporarily Ordered Routing Algorithm(TORA) is a hybrid distributed routing protocol for multi-hop networks, in which routers only maintain information about adjacent routers .Its aim is to limit the propagation of control message in the highly dynamic mobile computing environment, by minimizing the reactions to topological changes. Although, it mainly uses a reactive routing protocol, it is also enhanced with some proactive approaches. It builds and maintains a Directed Acyclic Graph (DAG) from the source node to the destination. There are multiple routes between these nodes in DAG. It is preferred for quickly finding new routes in case of broken links and for increasing adaptability. TORA does not use a shortest path solution, and longer routes are often used to reduce network overhead.

III. OPEN ISSUES AND CHALLENGES

A FANET is somewhat different from traditional MANETs and VANETs; however, the fundamental idea is the same: having mobile nodes and networking in an ad-hoc manner. Hence, in a FANET, some challenges are valid as in a VANET while facing with additional challenges. Although, many researches have been performed to increase the efficiency of network with flying nodes, there are still many unsolved problems, which should be explored in future works:

a)National Regulations: UAVs are increasingly used in many application areas, and they get their places in the modern information age. While UAVs increasingly become a part of each country's national airspace system, most of countries' current air regulations do not allow controlled UAV operations in civil airspace. This can be seen as the biggest current barrier to the development of UASs in civilian areas. Therefore, there is a serious need to define distinctive rules and regulations to integrate UAV flights into the national airspace.

b)Routing: In a FANET, due to the fast movement of UAVs, network topology can change quickly .Data routing between UAVs faces a serious challenge, which is different from low mobility environment. The routing protocols should be able to update routing tables dynamically according to topology changes.Most of previous routing algorithms in MANET are partly fail to provide a reliable communication between UAVs. Therefore, there is a need of developing new routing algorithms and networking model for constructing a flexible and responsive integration model.

c)Path Planning: In a large-scale mission area and multi-UAV operation, cooperation and coordination between UAVs are not only desirable but also crucial feature to increase efficiency. In the operation theatre, there can be some dynamic changes like addition/ removal of UAVs, physical static obstacles, dynamic threats (such as mobile radars), etc. In such cases, each UAV has to change its previous path, and new ones should be re-calculated dynamically. Thus, new algorithms/ methods in dynamic path planning are required to coordinate the fleets of UAVs. jitter, packet loss, etc. Defining a comprehensive framework for QoS -enabled middleware is a crucial challenge that should be overcome due to the highly mobile and dynamic structure of FANET.

d)Integration with a Global Information Grid (GIG): GIG is a worldwide surveillance network and computer system intended to provide Internet-like capability that allows anyone connected to the system to collaborate with other users and to get process and transmit information anytime and anywhere in the world. A FANET should connect to future Information Grids as one of the main information platforms to increase efficiency of a UAS by using a UAV's communication packages, equipment suites, sensors, etc.

e)Coordination of UAVs and manned aircrafts: It is inevitable that, in the future, flights of UAVs with other manned aircraft are likely to increase. This coordination will enable the destruction of enemy aircraft with minimal losses. At the same time, these UAVs can be used as electronic jammers and for real time video reconnaissance in enemy areas. Therefore, the collaboration of UAVs and manned aircraft should be in a networked environment.

IV.CONCLUSION AND FUTURE SCOPE

The role of UAVs is increase in almost all areas and they will play an prominent role in a large operation area. UAVs need to cooperate with each other in order to perform their task especially in areas that are inaccessible from the ground. Thus cooperating UAVs form a multi UAVs system. Which also aims to decrease the mission completion time and increase the reliability of the system.

In literature there are many routing protocols in FANET and many of thus protocols are not directly applicable for FANET. For the future work a new routing protocol is needed to implement and update existing protocols

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