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Routing Flying ad_hoc Networks (FANET) flight systems: A Survey

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Abstract - *One of the major designing problems for multi-purpose air force fleets is the communication that is important in inter-aircraft cooperation. If all of the planes are directly connected through infrastructure, like ground baseor satellite, the link between the flight paths can be realized through the same infrastructure. However, infrastructure-based communication architecture limits the capabilities of multi-purpose systems. Connected networks between (unmanned aerial vehicles) UAVs can solve the problems caused by a BM network based on fully integrated infrastructure. This paper examined Ad-Hoc (FANETs) transportation networks, which is a specialized network for routing flying system. First, the differences between FANET, MANET (Mobile ad hoc network) and VANET (Vehicular ad hoc network) networks were made clear, and after introducing the main challenges of designing the existing FANET protocols and routing flying systems were examined according to these protocols*

Key Words: flight systems, FANET, UAVs, flight system routing, Vehicular ad hoc networks (VANETs)

1.INTRODUCTION

The routing algorithms are divided into two static and dynamic categories. In the static method, forwarding/routing table is manually configured and during configuration router is adjusted and stays constant over time. Any changes to this table are also applied by the network administrator. In the dynamic method, the routing table is updated every T seconds based on factors such as the latest topology status (the shape of the network devices and their links) or the network traffic. From another view, these algorithms can be categorized into “Global Routing Algorithm” and “Decentralized Routing Algorithm” [1]. In a centralized way, each router needs to collect the information of all routers in the network and their relationship, and after the formation of the network graph, uses a search algorithm to find the shortest route suitable for the algorithm to find the best route between the two routers such as Dijkstra Shortest Path Algorithm. These algorithms are also called (Link State Algorithm) LS algorithms [2]. In a decentralized method, the routers do not have complete information about the network infrastructure and can only communicate with the routers directly associated with them (neighbouring routers). Then, at regular intervals, each router sends its routing tables only to neighbouring routers, so these routers can be based on the values they computed themselves, complete their chart and determine the route between different routers. These algorithms have very little temporal complexity. These algorithms are called Distance Vector Algorithm (DV) [3].

Before the flight, the pilot provides the flight plan including the route, altitude and speed of the airplane to the traffic control unit and the air traffic control unit gives each aircraft an invisible route to fly so that the planes do not collide. In fact, aircraft must be apart at least 16 kilometer from the sides, 300 meters from the top and bottom, and for 10 minutes flying forward and backward, so that they feel comfortable not to have collisions. On the other hand, most planes have radar on their nose, responsible for announcing bad weather conditions or the presence of aircraft and other objects in front of the airplane [4]. The radar is a radio device used to detect objects and measure some of their features with radio waves. The radar has a transmitter, a receiver, and one or more antennas. The traditional use of radar and its place of birth and its growth in are in military and aeronautical industries. Military radars are built for monitoring, target tracking, navigation guidance, and visibility behind obstacles. Civilian radar applications are in satellite imaging systems, ship and aircraft guidance, meteorology, traffic control and smart cars [5]. How the radar works on the plane is by using short radio waves that it emit. In fact, these waves are reflected after facing obstacles or clouds, and the receiver recognizes the aircraft with regard to the intensity and time of the wave, the type of obstacle and its distance to the plane. This information is displayed by the radar on the pilot's screen [6]. Indeed, the radar is a device for collecting information from objects, especially at distances where by using electromagnetic wave analysis, information like distance, dimensions, velocity, and target properties are specified. As most modern aircrafts fly very fast at high altitudes, the pilot cannot track down the ground because the planes fly above the clouds and he does not have any sights on the ground, so the pilot and the air traffic control unit requires electronic systems to control the aircraft and routing [7]. The rest of the paper is organized as follows. Section 2 will be the literature review. Section 3 describes the methodology, and Section 4 is the conclusion.

2. Literature overview

Mobility is one of the most prominent features of the network whose result is new problems for MAC layer in ad hoc network. Given the high mobility and the various distances between the nodes, the quality of the bonds in FANET network is usually fluctuating [8]. Changes in the quality of the bond and the termination of the transplant are affected by the design of the drug. Package delay is another problem of designing MAC FANETs, particularly for real-time applications where packet delay time is limited and new challenges are imposed [9]. Fortunately, there are some new technologies that can be used to meet FANET requirements in MAC layer. Directional antennas and fully bi-directional propagation circuits with multi-packet receivers are promising examples of technological advances that can be used in MAC layer of Ad-Hoc(FANETs) network[10].
The conductor antenna has several advantages over the distributor antenna for FANET network, which is presented as a subset of the physical layer. In addition to the advantages of using a directional antenna, it brings unique design problems, especially for MAC layer, while many MAC layers have been proposed for FANET and MANET networks [11]. There is little research on the design of MAC layer in ad hoc FANET networks with conductive antennas. In conventional wireless communications, reception and transmissioncannot be performed simultaneously [12, 13]. With the recent advances in radio circuits, it is now possible to realize a completely two-way communication on a channel. One ofthe other limitations of conventional wireless communications is the receipt of packages. If there is more than one sender, the receiver cannot receive all packets properly. Fortunately, data from more than one source with the help of radio circuits with a multi-packet receiver is possible. The radio circuits with a multi-packet and fully-bi-directional receiver have produced significant effects on MAC layer of ad hoc FANET network [14].
Channel state information (CSI) is one of the most important transmission parameters through two-way radio waves, and it is almost impossible to determine for highly dynamic media environments. By regular updating the status information of UAVs channel, they can have the latest channel status information at any time. The status-based structure eliminates the collision status of the packet collision channelstatus information. The results of the performance of the proposed MAC layer have shown that the layered substrate effects are incomplete, even if knowledge of the channels [15]. Initial analysis of FANET network experiments designed with our network routing protocols exist. One of the first Flight Experiments with Network Architecture is done in SRI International (SRI). In this study, the distribution-based topology (TBRPF) based on the return protocol, which is actually an active protocol, has been used as a network layer to minimize overhead. Due to the high mobility of the nodes of FANET network, storing the routing table is not desirable in an efficient way [16]. However, finding duplicate routes before delivery of each packet in response routing can be comprehensive. A strategy, based on the location information of each node, can meet the requirements of the FANET network. Although in the early network implementations, the use of our network routing strategies was used, most grid- based network routing algorithms are not ideal for specific cluster problems, such as rapid changes in the quality of links and high mobility of nodes. Therefore, special network routing solutions for FANET network have been developed in recent years [17].
Another set of routing solutions for the hierarchical proxy server network has been developed to address the scalability problem of the network. Here, the network includes a number of nodes located in different areas of practice. Each group has a team and all the nodes in the transfer range are directly from one team to another [18]. Aleader witha higher level of drone or satellite is directly involved, or indirectly as a representative of the entire group. On the other hand, the head of the team can distribute the data through the distribution among the group members. This model can produce favorable results when the operating area is large and the number of drills is high.

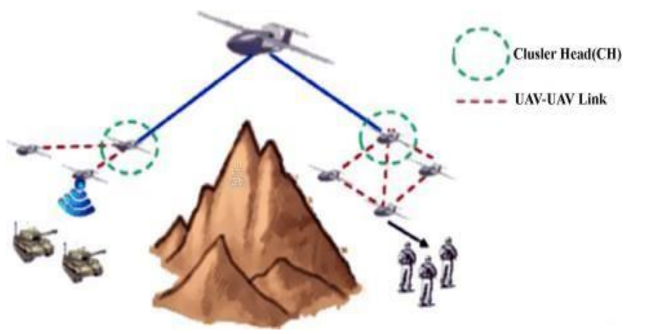

Figure 1: Hierarchical routing in FANET[27]

3. Overview of research methodology in FANET

In methodology, first, the problem of nodes' mobility was investigated and for that a method of forming the group algorithm was proposed. The multipurpose UAV system was created using the data-driven algorithm approach and architecture was presented for their relationship. The Pheromone model of the case was examined, considering the location of several fast GPS-based methods, and then we introduced the proposed locator. Finally, we introduced three-way communication protocols that are a group of them that are based on topology.

It defines the node based on IP. It leads to the most promising routing protocols.

One of the most important problems is the hierarchical routing design of group formation. The prediction of nodes' mobility is developed by the group formation algorithm for FANET network. The moving structure of FANET network nodes is due to the frequent updating of the group and the mobility of the group with the aim of solving this problem to predict the update of the network topology. The prediction of the dynamic structure of the spaceships is carried out with the help of the tree structure prediction algorithm and the time for the expiration of the mobile model. With this model, a set of weights is given to the UAV and the UAV that has a higher weight among the neighbors is selected as the head of the team. Simulated studies show that the choice of team leader can increase the stability of teams and head groups [19].

Data-driven routing algorithms can also be used for a network of services. UAVs are regularly produced for specific missions, and it is difficult to adapt multi-task systems to different missions. Data-driven routing solutions can be used for a variety of applications for multi-drone systems. The distribution model is commonly used for some type of communication architecture. It automatically generates connected data called an emitter and is a consumer of data that is commonly known. Data-centric solutions require aggregation and data compression in an executable network. Unlike flood, it only plays the recorded data type / content for subscription. In this case, data transfer from one point to several points can be preferred to data transmission fromone point to a point [20].

Data-driven communications are divided into three types:

1. Analyzed Space: The parts can communicate at any point.

2. Analyzed time: Data can be sent immediately or later to subscribers.

3. Analyzed flow: Delivery can be carried out with high confidence.

This model can run for systems including a limited number of drills with predetermined paths that require less collaboration. Routing is one of the most challenging problems in FANET network. Given the unique challenges of FANET network, existing network routing solutions cannot meet the network requirements. Peer-to-peer communications are essential for coordinating and preventing multi-dual system interactions [21]. However, it may be used by the network to collect environmental information through wireless sensor networks that generate different traffic patterns. All data is available to a limited set of drills that directly communicate with the communication infrastructure. Data-based routing is a promising method for network-based services. With the help of the subscriber architecture, the deployment of data-centric algorithms, multi-user systems that support various applications can be made [22].

The airborne nodes of FANETs are transmitted at speeds of 30-460 km/h, leading to topological changes, which in turn causes linking vibrations and failures. FANETs are used for highly sensitive applications such as traffic monitoring, remote sensing, crash monitoring, search operations, border monitoring and relay networks. These applications need accurate and fast delivery of information. Hence, the most important challenges that need to be addressed by airborne networks and routing layers are high reliability and delays in delivery of limited data.

The advantages of using ad hoc flight system are the following [23]:

1. Cost: The cost of flying and the cost of maintenance of small UAVs are much lower than a large UAV. Scalability (ability to change the field of action): Using a UAV only supports a limited amount of field coverage, whereas multi-drone systems can easily expand the field of operations.

2. Durability: If a mission is carried out by a UAV and failure happens, the mission will not be continued, but if a missile drone mission disappears, the mission continues with other UAVs.

3. Running Speed: Depending on the wider area covered with several UAVs, research has shown that missions are carried out by several drone drives faster.

4. Small radar cross-section: A large number of radar cross- sections create a very small cross-sectional area highly critical to military operations.

One model of mobility is the Pheromone model, where UAVs create a pheromone map that guides them in motion. Each UAV will mark the areas it scans on the map and share the map of the pheromone with others. To maximize the area covered, UAVs prefer to fly in areas with fewer symptoms of pheromone odor (marked points). In FANET architecture routing has a very high significance that due to the high speed of the UAVs and the change of position, they do not meet the needs of these networks alone. In this regard, the following fast GPS methods are proposed based on routing [24]:

AGPS: This method uses an auxiliary station like a telecommunication tower or information on the Internet to improve the location.

DGPS: In this method, a ground station that knows its exact position receives its position information from the satellites and matches its position. The difference between these two is sending to the moving nodes and they also receive their position from the satellite Correct this amount.

GPS + IMU: Using the inertia measurement unit in UAV, position changes of UAV are calculated from the last exact position and sent to other network nodes.

One of the most important design problems for multi-drone communication systems is to make it very important for the UAV to collaborate. If all drones are directly connected to a connected infrastructure, such as a ground station or a satellite, the connection between UAVs can be realized through infrastructure. However, this architecture limits the communication of infrastructure based on the capabilities of multi-drone systems. The interim UAV network can solve the problems due to the fully-powered drone-based infrastructure. Here, the temporary flight of the specs (FANETs) is investigated, which is an ad hoc connection network in the UAV flight system. The difference between FANETs, MANETS and the VANETs is introduced for the first time, and then the main designer challenges are introduced. Along with the existing FANET protocol, research issues are opened and discussed [25].

There is a wide range of proposed routing protocols for FANETs. All of these protocols are intended to improve the package delivery ratio and provide latency and packet losses. Moreover, all features of the device, in particular the upgrade of the highs should be considered as shown in Figure 2. The routing protocols of FANETs can be categorized into three main categories based on the technique followed and the idea behind each of the protocols: (1) topology-based routing protocols, (2) swarm-based routing protocols, and (3) routing protocols based on the position of the routing protocols. We remind that topology-based routing protocols have been explored in detail because this review leads to the most important position-based routing protocols appropriate for these types of networks. These categories of routing protocols use IP addresses to define nodes and use link information in the network to send packets through the appropriate route. Protocols are classified as preventive routing, reactive routing, and hybrid routing [26].

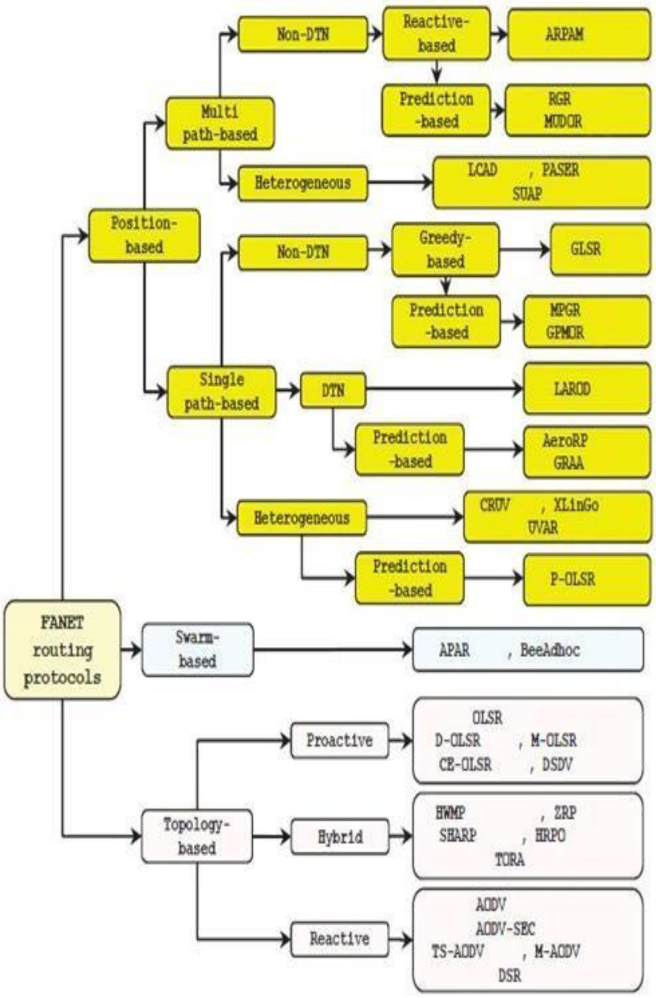

Figure 2: Dividing FANET routing protocol [26]

4. CONCLUSIONS

FANET protocols between the UAVs preserve different nodes on the ground, regardless of whether the nodes are fixed or mobile. Many benefits are provided by the use of this architecture. In the first step, it can expand sub-network coverage on the ground. In addition, fixed nodes on the ground can provide a trusted base network and higher bandwidth to provide better maintenance and control of these nodes. Different programs can be distinguished according to whether the information is shared between the nodes and the purpose of the exchange of information. For example, in VANETs, nodes on the ground can be used by UAVs to enhance reliability and ensure delivery of data. Moreover, aircraft can be used as a team for specific tasks or as sensors for different applications.

FANET airborne networks enable ad hoc routing between unmanned aerial vehicles, which is becoming increasingly important in military and civilian applications. The sensitivity of applications needs a scalable communication network and a latency range, efficient, and consistent with the intermediaries for data transfer. Due to the complexity of communication protocol, hardness, radio bandwidth, computing resources, and high dynamics, the desirable level of service quality preserves a hard task.

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