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INVESTIGATION FLYING AD-HOC NETWORK (FANET) BAESD ON ROUTING PROTOCOL

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Abstract: One of the most important design problems for the multi unmanned aerial vehicles systems is communication between UAVs. In a multi-UAV system, the communication between UAVs is provided with all UAVs connecting directly to the ground station via satellite or infrastructure. However, infrastructure or satellite based communication architectures restrict the capabilities of the multi-UAV systems. Infrastructure or satellite-based communication problems of multi-UAV systems can be solved with ad hoc networks among UAVs. This special ad hoc network structure is called as FANET. In this review paper, Flying Ad-Hoc Networks (FANETs) are reviewed which is an ad hoc network linking the UAVs. The communication protocols of FANET are explained first, and then the FANET scope are described. The differences between MANETs, FANETs and VANETs (Vehicular Ad-Hoc Networks) are also described. Along with the available FANET protocols, open research issues are also talked about. The paper provides an insight into the reviewed literature to reveal new aspects of research.

Keywords: Flying Ad-hoc network (FANET), Mobile Ad-hoc network (MANET), Vehicular Ad-hoc network (VANET), unmanned aerial vehicles (UAV) Ad -hoc Network, Routing Protocols

1.0 Introduction

FANET is one of As a result of the rapid technological advancement in computation, sensor, communication and networking technologies, Unmanned Aerial Vehicles (UAVs) promise new application areas for military and civilian areas such as, relay for ad-hoc networks, search and rescue operations, electronic attacks in hostile areas, ground target detection and tracking, automatic forest fire monitoring and measurement, wind estimation, disaster monitoring, remote sensing, airspeed calibration, agricultural remote sensing, etc. Though single-UAV systems have been in utilization for decades, rather than formulating and operating one broad UAV, utilizing a group of small UAVs has several benefits. Since, multi-UAV systems have also unique issues and one of the most high design challenges is communication [1]. FANET is comparably new concept of MANET and it has capabilities to tackle with situations where traditional MANET cannot do so [2]. This is relatively a new technology in network family where requirements vary largely from traditional networking model, such as MANETs and VANETs [3]. One of the most important design problems for the multi UAV systems is communication between UAVs. In a multi-UAV system, the message between UAVs is provided with all UAVs connecting directly to the ground station via satellite or infrastructure. However, infrastructure or satellite based communication architectures contain the capabilities of the multi-UAV systems. Infrastructure or satellite-based communication problems of multi-UAV systems can be solved with ad hoc networks among UAVs. This special ad hoc network configuration is called as FANET [4]. FANET is a subset of VANET. Usually, the topology of FANET change much commonly than MANET or vehicle ad hoc network (VANET). In FANETs, two types of communication take place: UAV-to-UAV communication and UAV-to-Infrastructure communication. In UAV-to-UAV contact, two UAVs can either directly communicates with each other i.e. Single Hop Communication takes place or a Multi-Hop Communication path can be constructed over the other UAVs. In UAV-to-Infrastructure Communication, UAVs communicate with a fixed infrastructure such as a satellite or a ground station [1]. In this review paper, Flying Ad-Hoc Network (FANET), which is generally ad hoc network among UAVs, is reviewed as a novel network family. The differences between Vehicular Ad-hoc Network (VANET), Mobile Ad-hoc Network (MANET) and FANET are explained.

FANET is cooperative reconfigurable, autonomous network of UAVs/MAVs. It is preferred for dangerous and time consuming tasks because of its long endurance where manned missions may be risky and put some constraints.

Flying Ad Hoc Network [5]

Figure 1.1

It is a new form of VANET in which UAVs are flying in the air with high mobility as compared to terrestrial vehicles. It is similar to multi-UAV system but differs in communication method. If the communication between UAVs is realized by ad hoc network then only the multi-UAV system is called FANET system. Scalability, survivability, speedy task completion by implementing higher number of nodes is advantages of FANET architecture. In infrastructure mode, UAVs communicate to ground station or satellites and in non-infrastructure mode, they communicate with surrounding nodes with single or multi hop which extends surveillance area. FANET altitude is decided according to application. It may extend from minimum 100 m to maximum 10 km. Thus transmitting signals get affected by atmospheric conditions and manmade structures, mountains, forest etc. UAVs are moving with high velocity i.e. 30 km/hr to 460 km/hr. In FANET, for localization, GPS, beacon nodes and proximity based location methods are used .Hence, lighter payloads are preferred for UAVs so that power required for lifting weight will be less. Also its velocity will be less affected [5].

2.0 Related Work

Ku!deep Singh [2] described the experimental analysis is carried out on AODV, DSDV and OLSR routing protocol for FANET environment using NS2 simulator. NS2 can simulate both types of networks wired and wireless and NS2 can simulate various types of communication protocol like UDP, TCP. In FANET, MAVs changes position very frequently. Due to this there is a rapid change in topology. So it is very necessary challenging task to find a suitable routing technique for FANET. In this paper show OLSR protocol is better than other two protocols. ***Md. Hasan Tareque [3]*** proposed the FANETs are surveyed a long with its challenges compared to fixed ad hoc network. In recent years, UAVs are being used in increasing number of civil applications, such as policing, fire fighting, etc. FANET must support both peer-to-peer communication and converge cast traffic at the equivalent time. The distances among FANET nodes are much higher than in MANETs or VANETs [1]; so higher range of communication is needed. FANETs are then classified into six main categories which are critically analyzed and compared based on various performance criteria. Finally, several open research issues related to FANET routing protocols to move researchers work on these open problems. ***Dr. Ilker Bekmezci [4]*** presented a method FANET test bed study. One of the most important design problems for the multi unmanned aerial vehicles systems is communication between UAVs. In this study, on the implementation of a FANET network architecture test environment are presented. FANET architecture can provide coordination between UAV in order to complete the mission successfully. This study presents a cost-effective and easily repeatable test environment implementation. ***Leena S. Parab[5]*** described the novel technique of compressed sensing. In compressed sensing method, instead of sampling the signal by Nyquist rate, signal is sampled by Sub- Nyquist rate i.e. sampling rate less than Nyquist rate. Thus, few samples are transmitted and signal can be recovered by using convex optimization technique. In FANET, numbers of UAVs are few. Hence, number of frequencies occupied will be sparse as compared to available wide spectrum band. It sparsely in form of number of UAVs is exploited and compressed sensing is implemented on coordination information which is shared between nodes data with reliable results compared to supervised methods. It is preferred for dangerous and time consuming tasks because of its long endurance where manned missions may be risky and put some constraints. ***Alexey V. Leonov [6]*** described the bee algorithm and the routing process based on the mentioned algorithm in ad hoc networks. The classification of FANET routing method is described. Owing to the experimental analysis, bio-inspired algorithms based on the bee colony were proved to show good results, having better efficiency than traditional FANET routing algorithms in most cases. Bee algorithm realized for solving various graph NP-complete problems, as well as routing problems in MANETs, VANETs. ***Emerson A. Marconato[7]*** described routing protocol must provide safety by finding an accurate and reliable route between UAVs. This safety can be obtained through the use of agile method during software based routing protocol development by mapping each FANET safety requirement into the routing design process. This process must be completed with a sequential safety validation testing with formal verification tools, standardized simulator and real-world experiments. They use the LARISS Architecture to guarantee the efficiency and accuracy of the whole system. They also use the model driven development method to provide model and code consistency through the use of formal verification tools. To complete the FANET safety validation, OMNET++ simulations (using real UAVs mobility traces) and real FANET outdoor experiment have been carried out. They confront both results to evaluate routing protocol performances and conclude about its safety consideration.

3.0 Communication Protocols For Fanets

In this section, the FANET communication protocols and the open research issues are explained.

3.1Multi Point Relaying (MPR): OLSR diffuses the network topology information by flooding the packets throughout the network. The flooding is done in such way that each node received the packets retransmits the received packets. These packets contain a sequence number so as to avoid loops. The receiver nodes register this sequence number making sure that the packet is retransmitted once. The basic concept of MPR is to reduce the duplication or loops of retransmissions of the packets. Only MPR nodes broadcast route packets. The nodes within the network keep a list of MPR nodes. MPR nodes are selected with in the vicinity of the source node. The selection of MPR is based on HELLO message sent between the neighbor nodes. The selection of MPR is such that, a path exist to each of its 2 hop neighbors through MPR node. Routes are established, once it is done the source node that wants to initiate transmission can start sending data. The whole process can be understood by looking into the Fig. 1.3 below. The nodes shown in the figure are neighbors. “A” sends a HELLO message to the neighbor node “B”. When node B receives this message, the link is asymmetric. The same is the case when B send HELLO message to A. When there is two way communications between both of the nodes we call the link as symmetric link. HELLO message has all the information about the neighbors. MPR node broadcast topology control (TC) message, along with link status information at a predetermined TC interval.

Flooding Packets using MPR

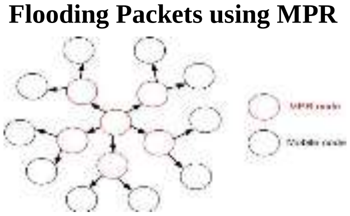

Figure: 1.2

Hello Message Exchange

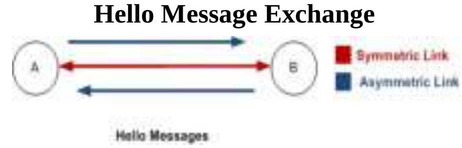

Figure: 1.3

3.2 Adaptive MAC protocol: The link quality fluctuates in FANET because of high mobility of nodes and continuously changing the distance between nodes. MAC design for FANET faces new challenges because of such link quality fluctuations and failures. Latency can also be another challenge. A directional antenna can be helpful in scenarios to increase the range of communication, spatial reuse, enhancing security. In [8], an adaptive MAC protocol has been proposed which uses an omni directional antenna for control packets transfer and directional antenna for data packets transfer. End to End Delay, Throughput and Bit Error Rate were improved with the use of this approach.

3.3 Token MAC: A Token based approach was proposed in [8] to update target information, to overcome the problem in traditional contention based protocols and link failures due to high mobility. Full Duplex Radios and Multi Packet Reception (MPR) were used to improve the MAC performance in a multi-UAV network environment. The delay is reduced with Full Duplex Systems as each node can transmit and receive at the same time and Multi-packet reception capabilities improve the throughput in multi-UAV systems.

3.4 Directional Optimized Link State Routing Protocol: A protocol is proposed which uses modified OLSR (Optimized Link State Routing Protocol) and uses directional antenna. In OLSR, the key step is selecting multi point relay (MPR). Reducing the number of MPR will result in reduced control packets transferred. In [8], as proposed by authors to transfer the packets, information about the destination is used and if the distance to the destination from source is less than half of maximum capacity of the directional antenna, then DOLSR is used otherwise, OLSR is used for routing. They have also proposed a new approach which reduces the number of MPR which results in reduced control overhead. The proposed approach reduces delay and enhances the overall throughput.

4.0 FANET Scope

In this section, various FANET scope are explained.

4.1 Extending the scalability of multi-FANET operations:

If a multi-FANET contact web is instituted fully established on groundwork, such as a satellite or a earth center, the procedure span is manipulated to the contact coverage of the infrastructure. If a FANET cannot converse alongside the groundwork, it cannot operate. On the supplementary hand, FANET is established on the FANET-to-FANET data links instead of FANET-to-infrastructure data links, and it can spread the coverage of the operation. Even if a FANET node cannot institute a contact link alongside the groundwork, it can yet work by conversing across the supplementary FANETs. This scenario is illustrated in Fig.1.4.

To extend the scalability of multi-FANET systems [9]

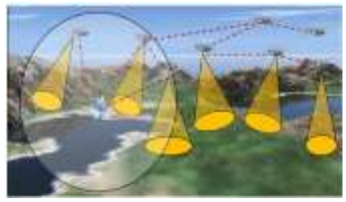

Figure 1.4

4.1.1 Reliable Multi-FANET Communication: In most of the cases, multi-FANET arrangements work in a exceedingly vibrant environment. The conditions at the beginning of a mission may change during the operation. If there is no opportunity to establish an ad hoc web, all UAV must be connected to an infrastructure, as illustrated in figure 1.5 (a). Though, across the procedure, because of the weather conditions changes, some of the UAVs may be disconnected. If the multi-UAV system can support FANET architecture, it can maintain the connectivity through the other UAVs, as it is shown in Fig. 1.5 (b). This connectivity feature enhances the reliability of the multi-FANET arrangements.

Reliable multi-FANET communication network [9]

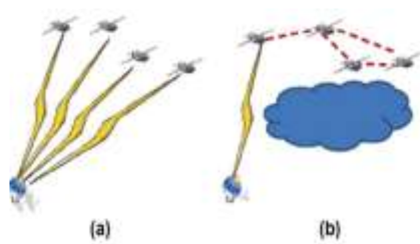

Figure 1.5

4.1.2 FANET Swarms: Small FANETs are extremely light and have limited payload capacity. In spite of their restricted skills, the swarm behavior of several tiny FANETs can finish complex missions. Swarm behavior of FANETs requires coordinated functions, and UAVs must communicate with each other to achieve the coordination. However, because of the limited payloads of small UAVs, it may not be possible to carry heavy UAV-to-infrastructure communication hardware. FANET, which needs relatively lighter and cheaper hardware, can be used to establish a network between small UAVs. By the help of the FANET architectures, swarm UAVs can prevent themselves from collisions, and the coordination between UAVs can be realized to complete the mission successfully [9].

5.0 Differences Between Fanet , Manet and Vanet

Wireless ad hoc webs are categorized according to their utilization, placement, contact and duty objectives. By meaning, FANET is a form of MANET, and there are countless public design considerations for MANET and FANET. In supplement to this, FANET can additionally be categorized as a subset of VANET that is additionally a subgroup of MANET.As a growing scrutiny span, FANET shares public characteristics alongside these webs, and it additionally has countless exceptional design challenges. In this subsection, the contrasts amid FANET and the continuing wireless ad hoc webs are clarified in a methodical manner [3].

5.1 Node Mobility: In FANET, the node's mobility degree is much higher than in the VANET and MANET. According to, a FANET has a speed of 30–460 km/h, and this situation results in several challenging communication design problems.

5.2 Mobility Model: FANET nodes move on fly in the sky. In multi-UAV systems, the flight plan is not fixed, if a multi-UAV system uses predefined flight plans it may not be successful, because of the environmental deviations or operation updates, the flight plan may need to be recalculated.

5.3 Node Density: Node density is defined as the average number of nodes in a unit area. FANET nodes are normally spread in the sky, and the distance between UAVs can be several kilometres even for small multi-UAV systems. Node density is lower in FANET system.

5.4 Topology Change: Due to higher mobility degree, FANET topology changes more regularly than MANET and VANET. When a UAV fails, the links that the UAV has been involved in also failed and it results in a topology update. Because of the UAV schedules and variations of FANET node distances, link quality changes very quickly, and it also causes link outages and topology changes.

5.5 Radio Propagation Model: FANET and the other ad hoc network operating environments affect the radio propagation characteristics. Radio signals are mostly affected by the geographic structure. Again, FANET nodes those are away from the ground can be driven remotely and in maximum case; there is a line-of sight between UAVs.

5.6 Computational Power: MANET nodes are battery powered small computers such as laptops, PDAs and smart phones. Because of the size and energy constraints, the nodes have only limited computational power. On the other hand VANETs and FANETs support devices with high computational power.

6.0 Conclusion

Communication is one of the most important design issues for multi-UAV systems. In this review paper, ad hoc networks among UAVs are reviewed as a separate network family i.e. Flying Ad-hoc Network (FANET). We define FANET and explain various FANET application scenarios. We also talk about the differences between FANET and other ad hoc network kinds in terms of node density, mobility, configuration change. We offer a comprehensive survey of the recent literature on FANETs and related challenges in a layered mechanism. Moreover, we also talk about open research issues for FANETs, with the cross-layer designs.

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