IOSR Journal of Engineering (IOSR JEN) **www.iosrjen.org**
ISSN (e): 2250-3021, ISSN (p): 2278-8719
PP 41-45

A Comprehensive Review on Various Applications and Challenges for Flying Ad hoc Networks

Sumit Kumar Gupta[1,2], Sachin Kumar[2], Sudhanshu Tyagi[3], Sudeep Tanwar[4]
Department of Electronics & Communication Engineering, SRMS College of Engineering, Technology and Research, Bareilly, Uttar Pradesh[1]
Amity School of Engineering and Technology, Lucknow Campus, Amity University, Uttar Pradesh[1,2]
Department of Electronics & Communication Engineering, Thapar Institute of Engineering & Technology, Patiala, Punjab[3].
Department of Computer Science and Engineering, Institute of Technology, NIRMA University, Ahmedabad, Gujrat[4].

Abstract: *Exponential growth of wireless ad hoc networks and its un-reliable nature on pre-existing infrastructure is attracting various industries for different applications. Flying Ad hoc networks (FANETs) is a latest technology of ad-hoc network which has captured the attention of investors due to its unique flying nature. FANET consist of different nodes that can fly at high altitude like balloons, unmanned aerial vehicles (UAVs), and have the ability to fly without the pilot. Common applications of FANET are surveillance, agriculture, photography, etc., and the challenges which can open the opportunity for researchers are multipath propagation, severe shadowing, traffic load balancing, mobility, congestion, high error rates, and so on. Based on the above issues the performance degradation of the network has results. In order to handle these challenges, the network traffic of FANET must be distributed in such a way that it should neither disturb the commercial flights nor the communication among the nodes that fly at high altitudes in a network. In this paper, we discuss various applications and challenges for FANET in details and explore the open issues for the researchers.*
Keywords:*MANET, FANET, UAV*

I. Introduction

FANET is another variant of mobile ad-hoc network(MANET). It is similar variant of Vehicular ad-hoc network(VANET). In vanet, the moving vehicles are considered as node whereas in fanet, flying objects are considered as nodes. These flying objects are known as unmanned aerial vehicles (UAVs). UAVs are able to build a network which is known as Flying Ad-hoc Network (FANET). UAVs are able to communicate to each other. Hence MANET, VANET and FANET are the different variants of Wireless Ad-hoc Network (WANET). So they have some similarities and some dissimilarities.

1) **Node mobility:** In FANET nodes are high speed UAV'S that's why it requires high degree of mobility. The speed of UAV'S may be 30 to 460 km/h
2) **Node density:** Node density in FANET is very much lower than VANET and MANET. The nodes in FANET are at extensive distance.
3) **Topology change:** The topology changes rapidly in FANET due to high mobility degree. This may lead to unexpected results of basic routing protocols.
4) **Radio propagation model:** The MANET and VANET nodes may be on the ground or near the earth but in FANET, the nodes appear far away the ground and in all cases, there is line of site (LOS) between UAVs which requires radio propagation models to be developed.
5) **Power consumption and network lifetime:** FANET communication hardware is powered by the energy source of the UAV. So it may not have the power consumption problems as in MANET but still it is the issue to create efficient design model for improved lifetime.
6) **Computational power:**Every UAV has sufficient energy and area to have high computational power. The only restrictionin computational power is the weight of UAV.
7) **Localization:** A vital issue of FANET is the localization. Due to high mobility and changing topology, it is important to know the location of each UAV. FANET needs highly accurate location data with less interval of time. For this purpose, UAV must equipped with inertial measurement unit (IMU). This can be summarized as in table-1

Table-1 Comparison among MANET, VANET and FANET

Characteristic	MANET	VANET	FANET
Structure	As in fig.2	As in fig.3	As in fig.4
Node Mobility	Less	High	Very High
Mobility Model	Irregular	Regular	Regularbut predetermined path
Node density	Low	High	Very low
Node location Identification	Low accuracy	Moderate accuracy	High accuracy
Network topology	Slow	Fast	Fast
LOS	Less required	Less required	Highly required
Power consumption	High	Very Low	High
Network lifetime	Need energy efficient	Not required	Need energy efficient
Computation power	Limited	High	High

The rest of the paper is organized as follows. Section II define single-UAV and multiple-UAV and their differences. Section III presents the application of fanet. What are the different challenges faced by the fanet is discussed in section IV? Finally, in section V we present our conclusion and highlight the future scope.

II. Unmanned Aerial Vehicle

Flying ad-hoc network is network of UAV as shown in fig.1. UAVs can fly without human with remotely controlled and can also fly without human automatically with predefined programmed [1,2]. Because of this feature, UAV has gotten huge popularity in different application like search and rescue operations, military surveillance, disaster management, wildlife management, remote sensing and many more.

Because of the advancement of technology, unmanned aerial vehicle (UAV) has unique features like adaptability, fairly tiny functioning expenditures, flexibility and simple set up [3], It has got a huge popularity in many areas. UAV can be utilized as single UAV and as multiple UAVs. In each single-UAV application, each grounded sensor device can communicate with UAV using star topology in which UAV worked as central device of the star topology. By the use of this topology, grounded sensor device can communicate with other grounded sensor devices. But with this single-UAV has some disadvantage like in peer-to-peer communication because of increased transmission distance and interference [4]. This problem can be solved by using high gain directional antenna instead omnidirectional antenna. As the application and advancement increased in electronic circuitry, single UAV coverts into multiple-UAVs. But single-UAV has more advantage as compare to multiple UAVs. Multiple-UAV has its own difficulties and the most important critical issue is communication among them [5].

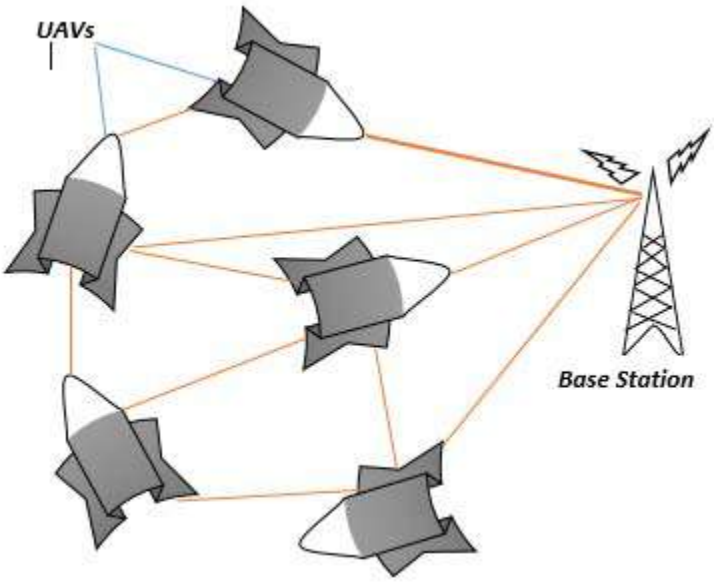

Figure 1: Multiple-UAV with base station

No doubt single-UAV has excellent utilization but multiple-UAV has its own advantage. Multiple UAV has a number of advantage and disadvantage like-

1) **Economical:** The maintenance and installation cost of large UAVs, is much higher than that of a small UAV (used in single UAV system) [6].
2) **Scalability:** The coverage area of single UAV system is small as compared to multi-UAVs, hence, coverage rate is low [7] while, multi-UAVs systems have the ability to adapt to a situation easily.
3) **Stability:** One of the major drawbacks of single UAV system is the single point of failure i.e. if a UAV fails to complete its task then the task will not be completed until another UAV is sent. While in multi-UAVs if one UAV fails then the task can be done other UAVs through different routes.
4) **Time wise efficient:** It is obvious that as compare to one UAV, multiple UAVs work faster to complete a task [8].
5) **Sustainability:** Multi UAV systems are more sustainable than single UAV systems.

Some challenges are also associated with Multi UAV systems which are given below:

1) **Cost of the equipment:** The cost of the complex hardware used for communication with either the ground station or satellite station is very expensive.
2) **Reliability:** The reliability of the communication is a big concern in multi-UAV system due to their high mobility. Very high mobility in multi-UAV system causes the communication links to make-and-break rapidly. Therefore, it will affect the reliability of the data.
3) **Coverage Area:** Coverage area is the transmission range of a UAV (in meter unit) in which it can remain connected with the ground station. This can be summarized as in table-2

Hence multiple-UAV has the advantage of low maintenance cost, high scalability, large coverage area, high stability, high efficiency, more sustainability along with disadvantage as less reliability and large cost of hardware. So the overall performance of Multiple-UAV is high and the reliability issue can be overcome by the use of interconnection of multiple-UAVs which is known as ad-hoc network of UAVs. Such ad-hoc network of flying unmanned aerial devices is known as Flying Ad-hoc Network (FANET).

Table-2 Comparison between Multiple-UAV and Single-UAV

Characteristic	**Multiple-UAV**	**Single-UAV**
Maintenance cost [6]	Less	High
Scalability [7]	High	Less
Coverage Area	Large	Small
Stability	High	Low
Efficiency [8]	High	Low
Sustainability [9]	More	Less
Cost of hardware	Large	Low
Reliability	Less	High
Information Speed	High	slow

III. Applications Of Fanets

There are many applications in which we can use of UAVs to perform any operation. The different operation can be done with the help of Single-UAV and Multiple-UAV as per the requirement. In this section, we discuss the different application of FANET.

1) **Search and rescue operations**- This is the most prominence area of application. UAVs are used to detect the human being in the affected area. First time such UAV networks were used during Hurricane Katrina in 2005, Fukushima disaster in 2011 and Nepal earthquake in the 2015 [9]. In the Natural calamity, the system has employed to detect human using survivor's mobile phone signal.
2) **Traffic monitoring**- Traffic monitoring is another prominence area of application. For managing the traffic, a large number of human personnel are required which can be replaced by UAVs. These UAVs removed the complicated infrastructure. UAVs can detect stuck situation and accident area in real time to provide the timeless help.
3) **Urban monitoring**- Urban monitoring can be performed with the help of military assistance. A multiple-UAVs system weredeliberated to lengthen the range of observation operations by forming a chain of UAVs using multi-hop communication [10]. A street Monitoring scheme can be formed by using UAVs as discussed in [11].
4) **Environmental monitoring**- There are a number of parameters which needs to be monitors under environmental condition like humidity, temperature, light intensity, pressure and pollution levels. These are monitored with the help of sensors but with the help of UAVs, these parameters can be attributed more accurately and analyzed where sensors cannot reach easily. In [14] describe how the UAVs are equipped with pollution sensors which are used to execute pollution measurements.
5) **Forest Monitoring**- Forest monitoring is very difficult task for human being due to very vast area. There are certain factors which needs to monitor like heat and fire risk. Such factors can affect the wild life which cannot be monitored. In such areas, single-UAVs or multi-UAVs can be effective to handle any situation. In

[12], author has discussed about the monitoring and measuring of fire in forest with help of a multi-UAV system.

6) **Surveillance** – Surveillance is the most important task of defense mechanism of any country. Human patrolling is difficult in some area which can be controlled by typical use of UAVs that can fly to observe a specific area. In surveillance, such UAVs can collect images of objects and area of interest over wide areas. AS in [13], a swarm of UAVs can detect not only unplanned human disturbances but also illegal border crossings.
7) **Agricultural management:**The monitoring of plant health observed under agriculture management which is known as precision agriculture (PA). In precision agriculture, the techniques and methods used to perform agricultural study such as condition of crop, properties of soil and content of water etc. [15]. The authors in [16] provide areview of cooperative remote sensing for management of water and control of irrigation using multi-UAV technique. The authors in [17] used the optimization of flight path for multiple-UAVs in agriculture applications.

IV. Challenges In Fanet

As the advancement in technology increases, the new challenge will come. No doubt FANET has solved a lot of problem in difficult situation as we have seen in application of fanet section in this paper. As the applications increases, New challenges comes in implementation of different area like in software and hardware. As in this paper we will discuss about the different challenges related to FANET.

1) Routing Protocols: Routing is the way of transmitting data from source to destination in an efficient way. So it is the most valuable challenge to transmit data efficiently. In literature, we have seen different routing protocols related to UAVs as shown in figure 2.

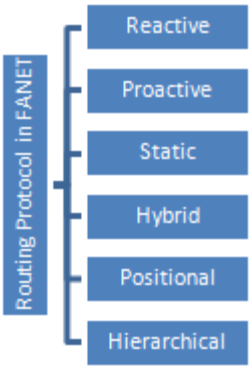

Figure 2 Different types of Routing in FANET

2) **Mobility Model:** The another challenge of UAV is the mobility of the different UAVs in a particular fashion so that they can communicate to each other efficiently. Mobility model shows how the different UAVs can move in their path and communicate to each other. It is also calculating if any UAV suddenly stop working then it will replace by another UAV and update in the system.
3) **Flying Regulation:** The applications ofUAVs are increasing day by day in many different fields. Every country has their own rules and regulation for aviation but such UAVs are not allowed for aviation in public domain [4]. So this is the biggest challenges for controlled UAV in public domain in those countries.
4) **Quality of Service:** UAVs are used in many different applications so it is most important that the information must pass to base station in good quality condition and timely delivered. The information can be video, text message, location etc. that can be used for crucial purpose. This is the crucial challenge to deliver the information timely and in good quality.
5) **Standardization of FANET:** Since FANET is used for a number of applications in which they use different UAVs for communication through satellite or GSM or CDMA networks. So they have to communicate with different frequency bands like C-band, Ku-band etc. Hence it is standardized the frequency band for communication among FANET network to reduce the interference.
6) **UAV payload Capacity:** FANET network is used for different applications in which they have to carry a number of equipments like single radar, infrared and/or thermal camera, imaging sensor etc. If UAV can have a number of equipments under the capacity of it, if it requires more equipments beyond its capacity then we have to use another UAV for completion of task. Hence it is challenge to fit all the required equipment within its payload.

7) **Coordination among manned air craft and UAVS:** In future, many applications will be such that UAVs have to send the data to manned air craft so that they can proceed further like war field and detection of mines etc. They can also be used as real time electronic jammers. So such coordination is the biggest challenge among unmanned aerial craft and manned aerial craft.
8) **Integration with a Global Information Grid:** Global information grid is a surveillance network and computer network which is used to provide Internet capability that allows every to connect to the system and to get process and transmit information anytime and anywhere in the world. A FANET must 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.
9) **Data Collection:** Data collection is method of gathering information among different UAVs that can transfer collected information to the base station. It is the most important process of any application of UAVs. So it is considered as a challenge for UAVs.
10) **Security:** Security always is a major challenge of any technology in any field. It is important to save data from unwanted or unauthorized persons so that they can't misuse the transferred information for their personal use. Terrorists may take control of the entire network or the subset of UAVs that communicate with the base station by jamming or spoofing the signals. Hence intensive research is going to make safe communication among UAVs and base station.

V. Conclusion

In this paper, we have discussed about different types of wireless ad-hoc network. We introduced the comparison among MANET, VANET and FANET. We discussed in detail about unmanned aerial vehicles, their types and their advantages and disadvantages. After that we explained their different application. As FANET is new emerging field of research, we discussed many challenges related to technology, routing topology, security, standardization of rules etc. In future scope, we have many more challenges and application field which needs to explore related FANET.

References

[1]. Alshbatat, A.I., Dong, L.: Cross-layer design for mobile ad-hoc unmanned aerial vehicle communication networks. In: 2010 International Conference on Networking, Sensing and Control (ICNSC). IEEE (2010).
[2]. Dey, N., Mukherjee, A.: Embedded Systems and Robotics with Open Source Tools. CRC Press (2016)
[3]. Ateef Altaf Munshi, Shikha Sharma and Dr. Sandeep Singh Kang: A Review on Routing Protocols for Flying Ad-hoc Networks, Proceedings of the International Conference on Inventive Research in Computing Applications (ICIRCA 2018) IEEE Xplore Compliant Part Number: CFP18N67-ART; ISBN:978-1-5386-2456-2
[4]. Ozgur Koray Sahingoz: Networking Models in Flying Ad-Hoc Networks (FANETs): Concepts and Challenges, J Intell Robot Syst (2014) 74:513–527 DOI 10.1007/s10846-013-9959-7
[5]. Anuradha Chauhan, and Ms. Renu Singla. "A Detail Review on Unmanned Aeronautical Ad-Hoc Networks." International Journal of Science, Engineering and Technology Research (IJSETR), May 2016.
[6]. Tareque, Md Hasan, Md Shohrab Hossain, and Mohammed Atiquzzaman. "On the routing in flying ad hoc networks." In Computer Science and Information Systems (FedCSIS), 2015 Federated Conference on, pp. 1-9. IEEE, 2015.
[7]. Kaur, Simarjot, and Meenu Talwar. "Routing Strategies in Flying Ad-Hoc Networks." Journal of Network Communications and Emerging Technologies (JNCET) www. jncet. org 6, no. 3 (2016).
[8]. Bujari, Armir, Carlos T. Calafate, Juan-Carlos Cano, Pietro Manzoni, Claudio Enrico Palazzi, and Daniele Ronzani. "Flying ad-hoc network application scenarios and mobility models." International Journal of Distributed Sensor Networks13, no. 10 (2017): 1550147717738192.
[9]. Digital Magazine Intelligence. INTELLIGENCE: better living through drones, 2015, https://www.theintelligence of things.com/article/betterliving-through-drones/
[10]. Olsson PM, Kvarnstrom J, Doherty P, et al. Generating UAV communication networks for monitoring and surveillance. In: 11th international conference on control, automation, robotics and vision (ICARCV 2010), Singapore, 7–10 December 2010, pp.1070–1077. New York: IEEE.
[11]. Reshma R, Ramesh T and Sathishkumar P. Security situational aware intelligent road traffic monitoring using UAVs. In: 2016 international conference on VLSI systems, architectures, technology and applications (VLSI-SATA), Bangalore, India, 10–12 January 2016, pp.1–6. New York: IEEE.
[12]. Merino L, Caballero F, Martinez-de Dios JR, et al. A cooperative perception system for multiple UAVs: application to automatic detection of forest fires. J Field Robot 2006; 23(3–4): 165–184.
[13]. Zafar W and Muhammad Khan B. Flying ad-hoc networks: technological and social implications. IEEE Technol Soc Mag 2016; 35(2): 67–74.
[14]. Alvear O, Calafate CT, Herna´ndez E, et al. Mobile pollution data sensing using UAVs. In: The 13th international conference on advances in mobile computing and multimedia, Brussels, 11–13 December 2015, pp.393–397. New York: ACM.
[15]. Torres-Sa´nchez J, Lo´ pez-Granados F, De Castro AI, et al. Configuration and specifications of an Unmanned Aerial Vehicle (UAV) for early site specific weed management. PLoS ONE 2013; 8: e58210.
[16]. Chao H, Baumann M, Jensen A, et al. Band-reconfigurable multi-UAVbased cooperative remote sensing for real-time water management and distributed irrigation control. IFAC P Vol 2008; 41(2): 11744–11749.
[17]. Li X, Zhao Y, Zhang J, et al. A hybrid PSO algorithm based flight path optimization for multiple agricultural UAVs. In: 2016 IEEE 28th international conference on tools with artificial intelligence (ICTAI), San Jose, CA, 6–8 November 2016, pp.691–697. New York: IEEE.