

Origin, Applications and Challenges of Unmanned Aerial Vehicle (UAV) In Flying Ad Hoc Network**Manjit Kaur¹, Sahil Verma^{2*}, Kavita³**¹Assitant Professor, School of Computer Science and Engineering, Lovely Professional University, India, manjit.12438@lpu.co.in^{2,3}Associate Professor, School of Computer Science and Engineering, Lovely Professional University, India, sahilkv4010@yahoo.co.in, dhullkavita@yahoo.in

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Abstract – The drones which is common term used for UAV are the unmanned aerial vehicles which have a great prospective in every of aspects of development. These unmanned vehicles are extremely beneficiary in the situations where originating the information by involving a human is a great threat and is required to avoid and thus these unmanned vehicles performs the duty of replacing the human’s participation in these tasks. The development in this field has been quite fast and has led to the making of highly advanced drones which are actively used in many civil and military operations in flying ad hoc networks (FANET). As it is seen all the essential tasks cannot be performed by a single unmanned aerial vehicle and hence multi unmanned aerial vehicle systems have been engaged. The most important point to be emphasized and to be worked on is the communication between these UAV. It is easy to construct an infrastructure to which all the UAV could be connected but this type of technique would limit the capabilities of the UAV. There is a requirement of ad hoc network which plays a crucial role in the communication process. This paper reviews the complete activity of this technology, from its origin to the present scenario of the modern world with its application used in FANET. The paper aids the reader to understand the development of this technology as well as its importance in times to come.





Keywords – *aircraft, drones, multi – UAV, FANET, Unmanned Aerial Vehicle*





I. INTRODUCTION

A drone that is well-known as Unmanned Aerial Vehicle (UAV) is an aircraft which do not have a human pilot on the panel. UAV has the facility to fly autonomously with the help of software-controlled flight plans in their systems or is remotely controlled by a human operator. The controlling is performed by sending radio waves from the ground controller which comprises the instructions which are required to be followed by the drone. It is a part of the Unmanned Aircraft System. It consists of a ground-based controller and the communication channel between the drone and the controller. They generally do not have a fixed shape or the way they move and are most often used for surveillance and monitoring

purposes. The most significant thing which is produced with the help of UAV is the aircraft which is used primarily in the protection service – police, defense and the army [1-2]. These aircraft have an important advantage of having comparatively less reaction time when it is required to prepare it for the take-off, and also, they do not require any additional infrastructure which in turn results in the reduction of cost of production. These vehicles can be quite beneficiary in producing the early warnings of the disaster and can assist the rescue operation when the communication is compromised. These can also carry out medical emergencies in times of crisis and can provide assistance in search operations in places where human involvement is dangerous. There are many forms of drones; such as multi-rotor drones, fixed-wing drones, single-rotor helicopter and fixed-wing hybrid Vertical Take-Off and Landing (VTOL) [3-6].

Table 1: Comparison of different types of drones

<p style="text-align: center;">Drones</p> <p style="text-align: center;">→</p>	<p style="text-align: center;">Multi-Rotor Drone</p> 	<p style="text-align: center;">Fixed-Wing Drone</p> 	<p style="text-align: center;">Single-Rotor Helicopter</p> 	<p style="text-align: center;">Fixed-Wing Hybrid VTOL</p> 
<p style="text-align: center;">Uses</p>	<p>Aerial photography, Filmmaking, Surveillance, urban surveying, construction, real estate, emergency response.</p>	<p>Pipeline and power line inspection, land surveying, mining, surveillance, aerial mapping, rural areas, and environmental management.</p>	<p>Laser Scanning - Aerial Light Detection And Ranging (LiDAR).</p>	<p>Wide range of commercial and military aerial applications, especially for drone delivery.</p>
<p style="text-align: center;">Price</p>	<p>~US\$ 5, 000 - \$ 65, 000</p>	<p>~US\$ 25, 000 - \$ 1, 20, 000</p>	<p>~US\$ 50, 000 - \$ 3, 00, 000</p>	<p>~US\$ 1,14,000 – \$ in development</p>

<p style="text-align: center;">Drones</p> <p style="text-align: center;">→</p>	<p style="text-align: center;">Multi-Rotor Drone</p> 	<p style="text-align: center;">Fixed-Wing Drone</p> 	<p style="text-align: center;">Single-Rotor Helicopter</p> 	<p style="text-align: center;">Fixed-Wing Hybrid VTOL</p> 
<p style="text-align: center;">Advantages</p>	<p>Good camera control, accessibility, easier to use, deploys quickly, small space required for vertical take-offs and landing.</p>	<p>Additional setup time, fast flight speed, larger area required for take-offs and landing, long endurance.</p>	<p>Able to hover vertically in the air, enduring flight time, heavy payload capability, strong and durable.</p>	<p>Greater endurance, cover longer distances, fly faster.</p>
<p style="text-align: center;">Disadvantages</p>	<p>Small payload capacity, limited flying times.</p>	<p>No hover, expensive, lot of space required for recovery, difficult to fly.</p>	<p>More training required, more dangerous, very expensive, harder to fly.</p>	<p>More difficult to land, drones cannot hover in the air but can move forward.</p>

Drones comprise generally two parts. The basic part of the drone is the frame which is very light in weight, and these frames are categorized based on the number of arms. It is observed that as we increase the number of arms of a drone the stability of the drone shows a significant increase. The other half of the drone comprises the propellers and engine. Unlike the frames, these are subjected to high weight. The main purpose of the propeller is to lift the vehicle into the air, and the engine is used to generate torque by converting the electrical energy generated by the battery. It is important to select the appropriate propeller and engine because it determines the weight lifting capacity of the drones, and also be used to determine the life of drone when subjected to different tasks. In order to carry out complex tasks which are difficult to be carried out using a single UAV a multi-UAV is adopted which comprises many single UAVs. Every single UAV is assigned a subtask and after completing its task, it communicates with the other UAVs about the progress of the task.

II. ORIGIN OF UAV

The countries which are the pioneer of this Ariel technology are the United States, Russia, Austria, and Germany. The first event which witnessed an unmanned flying vehicle (UAV) was in 1849, in which the drones were employed for the task of carrying the balloons which comprised the explosives for the attack. They were used by the Austrian forces to attack Venice. However, this first attempt was not completely successful as the influence of the wind was not taken under consideration and most of these drones missed the target and also some of them even fell back on the Austrian forces. The next stage of the development of drones was observed during the times of world war during the 19th century [7]. The main of the development was to perfectly aim at the predetermined target. The targets were generally the enemy camps, and the payload of explosives was required to be carried by these drones. In 1964 a massive upraise was seen in the development of drones, a project was introduced by the military of America which was named the Red Wagon which was witnessed due to more and more pilots losing their lives while entering the enemy territory. As time advanced these vehicles matured and were nurtured by their developers which led to the expansion of usage of these vehicles in different areas of interest.

These unmanned vehicles drones paved the path which clearly showed the possibility of advanced technology at a fair price and also with high fighting capability which can be launched without any risk involved to the personnel. Initially, these vehicles were used for the surveillance but as time advanced drones paved their way into many applications with its heavy use in military purposes. The research on this technology is still in progress and will be in its best form in times to come.

Flying ad hoc networks are called as air force UAV ad hoc networks. These are included unmanned aerial vehicles, permitting great mobility and also providing connectivity to remote areas [8]. Flying ad hoc networks can work either autonomously and by communicating the flow received from basic devices (land-based) to a remote server (fly in the air) or can also support other kinds of systems.

III. LITERATURE REVIEW

With the perpetual expansion of research on unmanned aerial vehicle, this work is on how to exploit the potential of unmanned aerial vehicles. It is on how to exactly manage the communication of information between the UAVs. This paper provides a study on crucial points of UAV origin, challenges, and its applications in different areas. In [9], studies the

characteristics and requirements of unmanned aerial vehicles used in civil applications. They presented the experimental results of existing communication technologies. In [10], highlighted on distinguished between infrastructure and UAV ad hoc networks. They focused on the research study of energy efficiency and routing. In [11], surveyed on Flying Ad hoc Networks which are connected with UAVs. They showed the difference between MANET, VANET and FANET. Finally, they present the design challenges of FANET and also discussed the challenges. In [12], the authors elaborated the work on UAV aided wireless communications, networking architecture and characteristics. The authors of [13] presented the different communications technologies with frequency parameters in US. They discussed the applications of UAV which are showing some issues related to laws, rules and regulations. In [14], authors surveyed on the issues and mechanisms of UAVs, also highlighted the use of UAV in the delivery of Internet of Things services. They also presented the architecture of UAV and also discussed its challenges and requirements. In [15], the authors provided a comprehensive study on the use of UAVs in wireless networks. They described the analysis of UAV challenges with mathematical techniques.

IV.APPLICATIONS OF UAV IN FANETS

These unmanned vehicles drones which were known for their heavy use in military are now being employed into various areas of interest which include being used by the stand alone entrepreneurs and other large companies to perform various tasks [16]. There are several applications which are described in different sectors:





Table 2: Uses of UAV in different sectors in FANETs



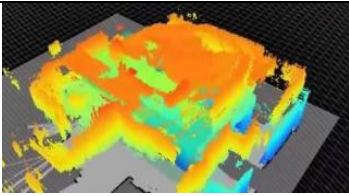

Sectors	Uses	Examples
Environment Sectors [17-21]	<ul style="list-style-type: none"> - Soil monitoring - Crop monitoring - Water, under water - Mountain inspection - Air quality monitoring [22] 	For example, UAV applied to agribusiness (by farmer) in order to monitor growth of crop in every season and also in order to help increase production crop.
Defense Sectors [23]	<ul style="list-style-type: none"> - Spying - Surveillance at border - Missile launching - Bomb dropping 	For example, UAV used as a medical delivery platforms in emergency cases in military area, especially for emergency medical

Sectors	Uses	Examples
	<ul style="list-style-type: none"> - War-zone medical supply - Combat aircraft 	equipment delivery. It has been used to transport the vaccines and pharmaceuticals, micro-biological and laboratory samples as well as patient transport.
Civil Sectors [24-29]	<ul style="list-style-type: none"> - Mining - Delivery - Construction - Photography, videography - Surveillance - Logistic 	For example, UAV also improves safety and provides real-time images in construction site. Surveying with UAV is economical and also provide comfort in surveying.

There are certain further useful UAV applications as discussed below:

Table 3: UAV applications with activities

Applications	Activities	Images
UAV Inspection and Monitoring	<ul style="list-style-type: none"> -industrial inspection -maintenance -repair of oil and gas platforms -Energy parks 	
UAV Surveying and Mapping	-remote sensing for surveying as well as mapping	
UAV Precision Agriculture	<ul style="list-style-type: none"> -harvest monitoring [30] -soil observation -irrigation observation 	
UAV Aerial Imaging	<ul style="list-style-type: none"> -high definition photos, films and videos -documentation with aerial imaging 	

Applications	Activities	Images
UAV Flight Dynamics	-study on control theory -automation of flight -reproduction	
UAV Swarming [31]	-swarm intelligence: coordination with self-organized systems -networking	
UAV Computer Vision	-computer vision: High-level understanding from digital videos and images. -Simultaneous localization and mapping research	
UAV Condition Survey and Civil Engineering	-structural analysis in Assessment -archaeology -heritage monument inspection	

V. CHALLENGES OF UAV

The greatest challenge which paving its way is the ever increasing demand of the drones for the commercial use. There are numerous issues surrounding UAVs as mentioned below:

- i) Shortage of technological standards and operational standards:** There is requirement to control UAV in safe mode and performance of the UAV should be consistent.
- ii) Vulnerabilities:** Knowledge of the UAV operations should be appropriate and control of UAV operations is mandatory.
- iii) Lack of government regulations:** There is also a requirement to follow safe facilitation and the integration of UAVs (laws, rules and regulations).
- iv) Inability to recognize:** User should avoid other airborne entity and other aircraft.
- v) Criminal Use, privacy, insurance, air safety etc.**

This use would turn out as a third party affliction and liability for the future of the airplane safety. One of the most commonly faced challenge is the base on which the drones operate which is on the radio frequency, if the base of the operation is compromised it would result in the radio frequency interference which results in loss of control on the drone or the UAV and

could result in various fatal events which might result in the risk of life for the human operating personnel. Also when the base is compromised it could also result in breach of the privacy of the confidential information which is collected using these unmanned vehicles. It concerns with the privacy because these vehicles have the massive capacity of holding onto the various collection of data of many of the individuals and hence there is a risk of breach of information [32]. Hence to resolve these situations it is necessary for the operating committee to lay down the restriction on the collection of the information by these unmanned vehicles.

They should keep in mind all the possibilities of the usage of this information by the intruders who would compromise the information. For instance the regulation of the United States has disabled the use of small UAVs which are hardly evident to a naked eye, and are also known as the Swarms. But this regulation has imposed a disadvantage in the case of the military teams as there is a heavy usage of these swarms in these sections. Hence the complete disability is not the answer to every problem; it is necessary that the legislation must adjust the regulations for the use of these vehicles and not completely disable its commercial use. As these unmanned vehicles are operated in the open air these drones are vulnerable to change in conditions of the weather, the tough weather poses heavy challenge to the drones which causes affliction in the pre-determined path of these vehicles. Due to this reasons all the missions which are assigned to these unmanned vehicles during the time of disasters like Tsunamis have often been deviated and are have also been a threat to the operator of the drone itself as these vehicles might lose the control due to this tough challenge.

The power supply to the UAV is another challenge which is more often faced; generally the drones are powered using the batteries which are not very advantageous as they do not provide enough power which could last higher durations. Therefore because of this reason it is not possible to collect the required amount of information in one go also it is not applicable in the spying from a longer distance as it would require a lot of power consumption and the other aspect where power supply is the issue is that it does not yield in the in-place analysis of the data and hence would result in storing the data for later analysis, which would require a larger memory which is to be carried by the drone. There exists challenges in every technology but the awareness is a key to the adoption of this technology in other fields and also ever increasing growth of the technology would result in the making of this unmanned vehicle drone which is less exposed to the external sources as well as more secure and reliable version of the present one.

VI. CONCLUSION

The present review paper describes various technical developments and application of the UAV in flying ad hoc network which is commonly known as drones from its root features to the development in the present modern world. There are many challenges which have paved their path and have been a threat to the development of this technology but it is seen that when there are higher number of opportunities which are offered by these unmanned vehicles in FANET when compared to the challenges or the questions which have been an obstacle. It is also observed that drones have many potential uses in various fields of development and hence are quite useful and advantageous for the present modern world.

The safety and the privacy of the people must be taken into consideration while deploying the policies concerning the usage of drones. This underlying technology has a great potential of providing assistance in every aspect of every emerging field but such an enormous and worth able technology must have a legal association which would allow the elimination of misuse of this technology by the external sources. Hence it is necessary that the potential benefits of these unmanned vehicles in flying ad hoc networks and their potential disadvantages must be stable in order to ensure the smooth functioning of the technology in future.

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