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Black box detection using UAV in FANETs

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Abstract

The major issue in airborne accidents is the retrieval of black box. An Unmanned Arial Vehicle (UAV) can be set inside the flight. The control of ejection is given to the pilot in the cockpit (manually). Flying Adhoc Network (FANET) is formed between the black box and the UAV. At the time of uncertain events like high jacking, engine failure etc., the pilot may trigger the UAV from its rear wing. The UAV should track the flight black box beacon signal, the UAV sends it to the Base Station (BS) via satellite. The upcoming idea is to setup UAV at the rear end of the aircraft (model airbus).The UAV is configured to send the response to the uncertain circumstances like highjack.

Keywords: UAV, Fanet, Cockpit (Controller), Beacon

1. Introduction

The wireless networks are classified into infrastructure and infrastructure-less networks. In infrastructure wireless networks, Base Stations (BSs) are fixed. Nodes moves randomly in the wireless environment and communication takes place with the help of the BS, which acts as the central controller. Cellular phone and paging systems are examples of infrastructure wireless network. It can efficiently utilize the network resources for controlling the activities like transmission scheduling, dynamic resource allocation and power control. But, forming and maintaining an infrastructure network is an uphill task.

In an Infrastructure-less wireless network, also called Adhoc wireless networks, nodes participate in routing by forwarding data to other nodes. The nodes that forward data are selected based on the network connectivity. In addition to the classic routing, ad hoc networks can use overflowing for promoting data.

Flying Adhoc Network (FANET) [1] is a self-organizing and adaptive network which enables users to communicate without any physical infrastructure. Devices should be able to detect the presence of other devices, which necessitates setup to facilitate communication and sharing of data and service. It enables the devices to maintain connections to the network as well as easily add and remove devices to and from the network. Figure 1 shows different types of ad-hoc networks.

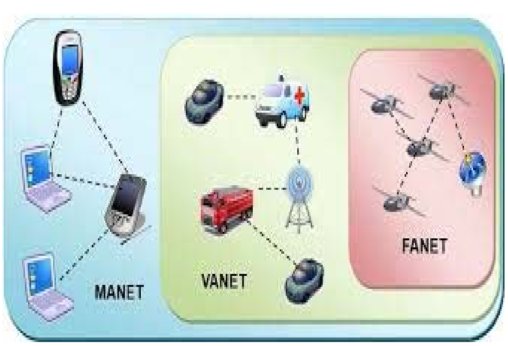

Fig 1: Types of Adhoc Networks

FANET is communication based. A FANET is formed by the communication between Unmanned Arial Vehicle (UAV) and Black box. UAV communicates with the black box which is connected with an Adhoc network in flying mode. The UAV connected with Black box device tracks the Black box.

As a result of the rapid technological advances on electronic, sensor and communication technologies, it has been possible to produce UAV systems which can fly autonomously or can be operated remotely without human intervention. Because of their versatility, flexibility, easy installation and relatively small operating expenses, UAV promises new ways for both military and civilian applications, including search and destroy operations, border surveillance, managing wildfire, relay for ad hoc networks, wind estimation, disaster monitoring , remote sensing and traffic monitoring.

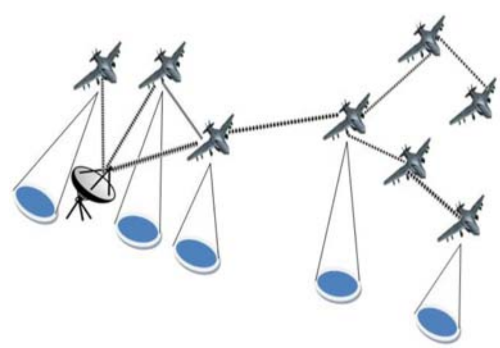

Fig 2: Fanet Communication

Though single-UAV systems are in use for decades, instead of developing and operating one large UAV, using a group of small UAVs has many advantages. However, multi-UAV systems have also unique challenges. Figure 2 shows FANET communication.

1.1 FANET application scenarios

In this section, different FANET application scenarios are discussed.

Extending the Scalability of Multi-UAV Operations

If a multi-UAV [2] communication network is established wholly based on an infrastructure such as a satellite or a ground base, the operation area is limited to the communication coverage of the infrastructure. If a UAV cannot communicate with the infrastructure, it cannot operate. On the other hand, FANET is based on the UAV-to-UAV data links instead of UAV-to-infrastructure data links, and hence can extend the coverage of the operation. Even if a FANET node cannot establish a communication link with the infrastructure, it can still operate by communicating through the other UAVs. This scenario is illustrated in Figure 2.

There are several FANET designs developed for extending the scalability of multi-UAV applications. The FANET design was proposed for the range extension of multi-UAV systems. It was stated that forming a link chain of UAVs by utilizing multi-hop communication can extend the operation area.

2. FANET

This explains the different mobility models in FANET.

They are a special case of Mobile Ad hoc Networks (MANETs). In a FANET, the topology of the network can change more frequently when compared to MANET or Vehicle Ad hoc Network (VANET). One of the most important design challenges of the multi UAV systems is the communication [3].

UAV systems fly autonomously without carrying any human help. Usage of UAVs promises new ways for both military and civilian applications ranging from search and rescue operations to disaster monitoring. In In multi-UAV network provides a group of small UAVs form a special kind of ad hoc network architecture. This type of networking architecture is called FANET with unique challenges in contrast to MANETs or VANETs.

In FANET, each UAV connects directly through the satellite or ground station to establish an ad hoc network among all UAVs. Ad hoc network between UAVs is one of the most effective communication architectures for multi-UAV systems. With the help of multihop communication schema, FANET architecture certifies that all UAVs are connected to each other and to the Base Station (BS) or Satellite continuously without any infrastructure, even if a UAV cannot directly communicate with the BS or satellite.

In this way, FANET not only transfers the collected data to the control centre immediately, but also supports the inter-UAV communication which is crucial to realize the collaboration among UAVs. FANET have high mobility degree when compared to other ad hoc network. However, because of high mobility of the UAVs, the topology of FANET nodes changes very frequently, and all-time connectivity becomes an important constraint for the FANET based multi-UAV task planning. In FANET, the distance between the UAV nodes is larger. High gain antenna is required to achieve longer range.

Long range transmission can also help to reduce hop count and enhance latency performance. Most UAVs perform real time operations like video transmission etc., where high data rate is required. This leads to high bandwidth requirement compared to MANET or VANET. FANET requires high speed as compared to the MANET and VANET.

FANET differs from MANET and VANET in many ways:

- ✓ Mobility degree of FANET nodes is much higher than the mobility degree of MANET or VANET nodes. The typical MANET includes mobile nodes such as mobile phones, laptops etc., and VANET nodes are vehicles such as cars bikes, FANET nodes fly in the sky.
- ✓ Due to the high mobility of FANET nodes, the topology changes more frequently than the network topology of a typical MANET or even VANET.
- ✓ Distances between FANET nodes are much longer than in the MANETs and VANETs. To establish the communication links between UAVs, the communication range must also be longer than in the MANETs and VANETs.

Liu [4] has proposed a UAV HAWK, a war flying tool. It is more accurate than a War walking or war driving tool. Since, HAWK can fly to any point in open space and an airborne Kismet can be set up with Global Positioning System (GPS) on HAWK, and produce a fine-grained geographical map of Wireless Access Points (WAPs) or routers. War driving and war walking are not able to provide such location granularity because it is not possible for cars and not convenient for people to access dead ends such as building roofs.

HAWK can also be used for search, rescue, and surveillance. It is able to sense a target mobile through its wireless signals, either cellular or Wi-Fi. For instance, modern smart phones are often equipped with Wi-Fi devices which send out probing signals intermittently. When a lost traveler or a survivor is searched and rescued from building debris after an earthquake, he can be positioned by localizing his active smart phones via HAWK flying slowly at a low altitude.

HAWK flies in the vertical plane around skyscraper to search a suspect hiding in a room and committing attacks via WiFi. The top diameter of HAWK is only 99 cm and its height is 25.4 cm. It can fly in both outdoors and indoors and conduct stunts that common large helicopters cannot do. The most related work to HAWK is WASP.

WASP is also a UAV and has the capability of way flying. However, it uses a mini airplane. It relatively maintains high speed and this limits its capability for surveillance because of the cruising speed requirement of locating an active mobile device. In contrast, HAWK can hover statically over a target and has an approximate maximum speed of 50 km/h.

HAWK [5] is developed as a generic aerial surveillance tool. Fully functional HAWK is built as a mini helicopter - Dragan flyer X6 [6] armed with Smartphone Nokia N900 as the wireless sniffer. A simple mechanical dynamics model is established for Dragonflies X6 and customized-Control laws for pitch, roll and yaw are developed. Maneuvers control X6's movement. The waypoint functionality for X6 to take for planned route is implemented. HAWK is designed as a generic aerial surveillance tool.

A Moore space-filling curve-based flight route is designed for HAWK to survey a specific area. To ensure that all target mobile devices are detected during flight, the minimum Moore curve level that is constrained by flight velocity and target packet transmission interval is derived. The Moore curve based flight route can also be optimized according to a digital map to avoid unoccupied areas and save power consumption for a UAV. From the surveillance flight, a

specific target pinpoints to a small hot area. If fine-grained target localization is required, then space-filling curve-based flight strategy in the hot area is to be recursively applied.
Heimfarth *et al.* [7] have dealt with UAVs for Wireless Sensor Networks (WSNs) that are vulnerable to failures that may lead to the disconnection of parts of the network, creating partitions in the network, isolating the sensor nodes. This problem compromises the final results achieved by the WSN operation, as those isolated nodes are not able to deliver their messages to the sink nodes [8]. A way to overcome such problem is to provide an alternative connection to support the connectivity via other types of nodes that repair the connectivity among the sensor nodes. In this work, UAVs are taken as relay nodes to guarantee the delivery of data produced by WSN nodes on the ground to the end users.

3. Existing System

Aircraft installed with UAV (drones) detects the black boxes, even if it is active in the network but not relaying the received signals.

- ✓ Aircraft model
- ✓ Black box designing and installation
- ✓ UAV

4. Proposed Work

The problem of isolating a minicomputer efficiently and establishing a smart drone along with a raspburrypi2 (Figure 3) enabled Wi-Fi connectivity with the black box beacon placed in the aeroplane is proposed. In the airbus model A320, the inbuilt drone is fitted inside the rear wing of the flight where the black box beacon is installed. The structure of the black box is given in Figure 4.

Fig 3: Raspburry (Pi2)

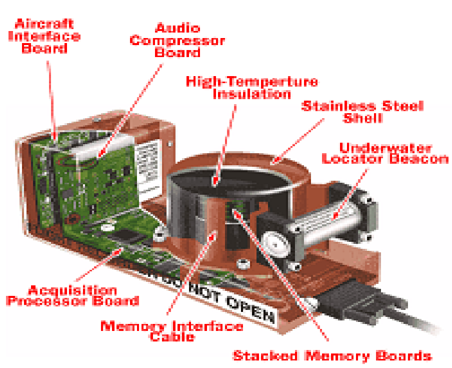

Fig 4: Black Box

The black box is placed with a tracking beacon and it is enabled to communicate with the UAV. At the time of uncertainty, the pilot may manually trigger the UAV from the aircraft so as to track down the black box. At the ejection time of the UAV, the following factors are to be considered.

- ✓ The altitude of the flight
- ✓ The airs density
- ✓ The speed and the angle of trajectory of the plane (aviation)
- ✓ The ejected time of sequences

Fig 5: Air Bus

The airbus model of the plane is mentioned to set the UAV. Model A320 is used as the testing prototype as shown in Figure 5. The Ejection process is the same as the escape ejection techniques used in the jet fighter.
The system includes the drones (Figure 6) as the prototype for the actual UAV and the intelligence of connecting a network enabled with TP-link supported raspberry pi2.
The overall system should work with a Wi-Fi supported network environment. The flying drones should be supported by the network zone.

Fig 6: Drone

5. Conclusion

Communication is one of the most challenging design issues for black box-UAV systems. In this paper, ad hoc networks between UAV and black box are surveyed as a separate network family, FANET. The differences between FANET and other ad hoc network types in terms of mobility, node density, topology change, radio propagation model, power consumption, computational power and localization are discussed. The design considerations like adaptability scalability, latency, UAV platform constraints and bandwidth are considered. UAV tracks the black box and sends the location information to the satellite from where it is sent to the Base Station (BS).

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