FLYING ADHOC NETWORKS – A REVIEW ON COMMUNICATION PROTOCOLS AND TOPOLOGY

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Abstract: *The rapid growth of wireless technology has a very broad impact in our life due to its lots of applications. One main characteristic is its sensors to sense the remote environment. Unmanned aerial vehicle (UAV) commonly called as drone has such sensors. A group of small UAV's connected in ad-hoc mode is called as Flying ad hoc network (FANET) which can fly autonomously or can be operated remotely without carrying any human personnel. FANET helps in disaster monitoring, search or military operation and computing its data. This paper focuses on the communication protocols and the topologies which is used and best suited for FANET.*

Key words: **UAV, FANET, ad hoc, base station, topology, communication protocols.**

1.Introduction

A UAV (Unmanned Aerial Vehicle) is an aircraft that can fly without a human pilot on board also referred to as a *drone*. Unmanned aerial vehicles have been adopted in many sectors such as military, agriculture, wildfire monitoring, border surveillance, or telecommunications. Ad hoc network connecting the UAVs together is called Flying Ad-Hoc Networks (FANETs). UAVs are continuously becoming more powerful, efficient, and cheaper to operate. FANET nodes are generally scattered in the sky, and the distance between UAVs can be several kilometers (Ilker Bekmezci,2013). As the technology continues to improve, the cost savings and enhanced data collection will continue to improve as well. Planes in the past are now able to be done as UAV. Drones could be equipped with cameras, sensors. Depending on the high mobility of FANET nodes, the topology changes more frequently than the network topology of any other ad hoc network. Various drones are shown in figure 1.

The existing ad hoc networks aim to establish peer-to peer connections. FANET also needs peer-to-peer connections for coordination and collaboration of UAVs. It collects data from the environment and relays to the command control center. A typical unmanned aircraft is made of light composite materials to reduce weight and increase maneuverability. This composite material strength allows military drones to cruise at extremely high altitudes. Drones are equipped with infrared cameras, GPS and laser. Different types of drones are shown in figure 1. An unmanned aerial vehicle system has two parts, the drone itself and the control system. The nose of the unmanned aerial vehicle is where all the sensors and navigational systems are present. The rest of the body is full of drone technology systems since there is no need for space to accommodate humans. UAV sensors capture data about both the external environment and the internal operating status of its own systems. This information is utilized by the autonomous control system to execute flight programs or relayed to a remote operator for operation of the craft. The communications system transmits data between the vehicle and ground control stations. A radio frequency system sends and receives information such as system status, location, and video. Node density can be defined as the average number of nodes in an unit area as shown in figure 2

Figure 1 Modern UAV's

Figure 2 UAV'S in an unit area

2. FANET

FANET can be defined as a new form of ad hoc networks in which the nodes are UAVs. Single UAV systems cannot form a FANET, it is valid only for multi-UAV systems. On the other hand, not all multi UAV systems form a FANET. The UAV communication must be realized by the help of an ad hoc network between UAVs (Ilker Bekmezci,2013). Drones are controlled by remote ground control systems (GSC). It moves around the environment, senses with the sensors on the UAVs and relays the collected data to the ground base as shown in figure 3. It requires radio communications for command and control. The following are the two ways of communications are: The uplink which send commands to the aircraft for flight and navigation equipment control. The downlink is to send flight status from the UAV to ground. The materials used to build the drone are highly complex composites designed to absorb vibrations, which decrease the noise produced. These materials are very light weight. Drones are now equipped with collision avoidance systems. UAVs.

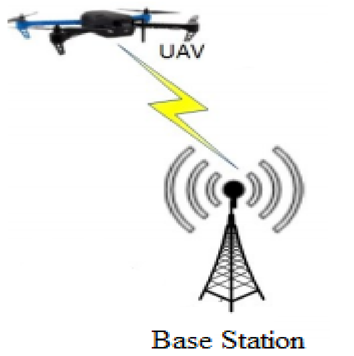

Figure 3 FANET Scenario

UAV operates in an autonomous manner, and the decisions are taken by each UAV in the air rather than on the ground.

3. FANET - COMMUNICATION PROTOCOLS IN VARIOUS LAYERS

Communication protocol is a system of rules that allow two or more entities of a communications system to transmit information. It uses well-defined formats for exchanging various messages. FANET communication protocols in the respective layers are discussed below.

3.1. *Physical layer:* The physical layer covers the basic signal transmission techniques, i.e. signal or modulation coding. Sequences of data bits are represented with different waveforms by changing the amplitude, frequency and phase of a signal (Ilker Bekmezci,2013) For developing sustainable and robust data communication architectures for FANET, the physical layer situations have to be well-defined and well-understood. Antenna structures and Radio propagation models are enquired as the key factors that affect FANET physical layer design (Anderson,2008). Two types of antenna are experimented on FANET, directional and omnidirectional. Omnidirectional antennas transmit in all directions while directional antennas transmit through a particular direction. If we are considering dynamic topology nature of FANET omnidirectional antennas suits for FANET, but the transmission range of directional antenna is longer compared to omnidirectional antenna.

3.2. *MAC layer* : The high mobility nature of the FANET causes some challenges on the MAC layer. Because of the high mobility and dynamic topology nature the distance between the nodes vary very frequently. It can cause quality fluctuations on links. This will directly affect FANET MAC design. Packet latency is another issue to be considered at MAC layer. An adaptive MAC protocol has been proposed which uses an omnidirectional antenna for control packets transfer and directional antenna for data packets transfer (Rieke,2009).

3.3 *Network Layer:* Commonly used proactive protocols in FANET are Optimized Link State Routing (OLSR) and Destination Sequenced Distance Vector (DSDV). Because of the high mobility of the FANET nodes, it is difficult to maintain the routing table. The reactive routing protocol (RRP) is also known as on demand routing protocol, means it discovers or maintains a route on demand. The routing table here is periodically updated, when there is some data to send, if there is no connection between two nodes, there is no need to calculate a route between them. Commonly used reactive protocols in FANET are Dynamic Source Routing (DSR) and Ad-Hoc on Demand Distance Vector (AODV). The primary purpose to select DSR is its reactive structure. In this protocol, repetitive path finding before each packet delivery become very difficult.

3.4 *Transport Layer:* The FANET designs success is closely related in establishing a reliable transport method particularly in a highly dynamic environment (Anderson,2008). The important responsibilities of a FANET transport protocol are due to the highly dynamic environment, reliability has become the most important factor in FANET communication architecture.

- Reliability: The main responsibilities of a FANET transport protocol are FANET transport protocol should provide support to various reliability levels for many FANET applications.
- Congestion control : The typical results of a congested network are the reduction in packet delivery ratio and the increment in latency
- Flow control : due to a fast sender or many senders, the recipient may be overloaded. Flow control can be a critical problem particularly for heterogeneous multi- UAV systems(Anderson,2008)

4. FANET TOPOLOGY

UAV networks fly higher up and they are going to fly together either in synchrony or maybe asynchronously. In UAV network, individual UAVs talk to one. Fanet does not use fixed topology. There are different topologies of the UAVs based on different structures of UAV networks. The common topologies for UAV are star, multistar, mesh or hierarchical mesh topology. UAV's can be deployed using ***star*** like topology using a ***mesh*** like topology.

4.1 FANET with Star topology

Star configuration is as shown in the figure 4. UAV's can be with single star configuration or a multi star configuration. In single star configuration UAV is directly connected to the ground station. UAVs would be routed through the ground nodes. This may result in blockage of links, higher latency and requirement of more expensive high bandwidth downlinks. In addition, as the nodes are mobile, steerable antennas may be required to keep oriented towards ground node (Frew, 2008). If the ground centre fails, there is no inter-UAV communication. In the case of multi star configuration the UAVs form multiple start topologies one loop from each group basically connects to the ground station. These are the UAVs which connect with the ground control station.

Figure 4 UAV's in star topology

4.2 FANET with Mesh topology

FANET can also be de deployed in a mesh like pattern as shown in figure 5. Mesh topology is a type of networking where all nodes cooperate to distribute data amongst each other. In case of mesh networks the UAVs are interconnected and a small number of UAVs may connect to the control centre (Jun Li,2013). Manages high amounts of traffic because of multiple devices and can transmit data simultaneously. A failure of one device does not cause a break in the network or transmission of data. Adding additional devices does not disrupt data transmission between other devices. There are usually multiple links on one or more radios for interference between channels, changes in transmitted power due to power constrains, changes in number of nodes, changes in topology, terrain and weather effects. A packet can pass through intermediate nodes and find its way from any source to any destination in multiple hops. Either it can be a flat mesh network or a hierarchical mesh network. Mesh network means, that there is multiple connectivity from one node to the other nodes in the network. So, mesh kind of configuration is useful in the case UAV networks because these UAV networks are very much fault prone faults of different types links and nodes and so on. In a FANET, the topology of the network can change more frequently than in any other network which becomes a very challenging task. In the ad hoc architecture, every node can act as a router. These networks are also known as FANETs: they have no central infrastructure; therefore, they are very robust.

Figure 5 FANET mesh topology

Mesh network can be used to configure a wireless mesh network to support the areas where network infrastructure is destroyed by disasters or disputes.

5. Conclusion

Communication is one of the most challenging aspect for multi-UAV systems. In this paper, ad hoc networks between UAVs are surveyed as a separate network family which is Flying Ad-hoc Network (FANET). It is discussed about the communication protocols and topology in FANET. It describes about the functions in various communication layers which will help for FANETs deployment. FANET typically uses star or mesh topology for a UAV networks. The comparison of topology between star networks and mesh network is been done. Mesh topology are flexible, reliable and offer better performance characteristics. In a wireless mesh network, nodes are interconnected and can usually communicate directly on more than one link. FANETs will be ubiquitous technology in the future.

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