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Research on UAV ad hoc network system design

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Abstract: **According to the special application environment and flexible and dynamic networking requirements of UAV network, a UAV network architecture design based on ad hoc network is proposed. This architecture provides a fully connected networking mode for UAV network, including the design of key technologies such as architecture, networking technology, routing protocol, etc., so as to meet the special application environment of UAV self-organizing network node moving fast and topological structure changing frequently, with high reliability and operability.**

Keywords: Ad hoc network; UAV; system design

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1.Introduction

In recent years, the development of modern war has shown an obvious trend of unmanned. UAV has many advantages in modern warfare. Its main operational characteristics include low cost, good concealment, strong vitality, no fear of casualties and easy replenishment, simple takeoff and landing, flexible operation, and support for multi-mission types. In order to meet the need of the future war, unmanned aerial vehicles (UAVs) are from the past simple auxiliary combat support functions such as training, reconnaissance surveillance to the communications relay, battlefield management, fire, damage assessment and early warning, electronic countermeasures, multi-function direction, such as attack, high and low empty full cover, stay long war zone, miniaturization, multi-function, high performance, the cluster operations is the main trend of military UAV, the significant operational effectiveness, low cost advantages of mass equipment damage loss is small, easy to make its are playing an increasingly important role in the war, many machine together is the precondition of realizing unmanned aerial vehicle (UAV) group of independent ad hoc network communication integration, In other words, the UAV network with strong communication ability, information perception ability and destruction resistance must be established [1].

2.Network architecture design

Compared with the traditional Ad hoc network, UAV has a broader network coverage, faster moving speed, which result in frequent changes in the network topology. At the same time, UAVs usually need to communicate with each other, cooperatively perform tasks with strong group mobility, which sets higher requirements for network communication [2].

Hierarchical design, which divides the entire communication protocol into a number of relatively independent sub-layer, is often used in network communication protocol design. One of the keys to the success of Internet technology stems from the adoption of a layered communications protocol structure.

Compared with wired networks and traditional wireless networks, mobile ad hoc networks have many different working environments. Therefore, the technologies used are quite different from those of networks. This difference is mainly reflected in the lower three layers of the network: the physical layer, Link layer, network layer. According to the characteristics of mobile ad hoc networks and the OSI reference model.

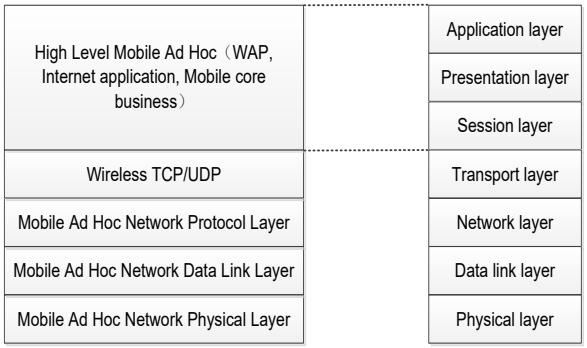

Figure 1 shows the architecture of mobile ad hoc networks.

Figure 1 Different layers in Mobile Ad Hoc Network

Each communication UAV supports a complete communication protocol stack structure. The protocol stack includes a complete communication protocol from the application layer to the physical layer. In view of the TCP/IP protocol family good scalable and robust, we proposed using TCP/IP protocol stack as target network protocol stack frame mouth due to the TCP/IP is not aimed at wireless communication network design, and its basic design concept is based on the strict hierarchical design thought, must be based on the framework of the existing expansion, make it suitable for target research network environment.

3.UAV networking technology design

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So far, most UAVs in the world have retained the characteristic of single aircraft to perform missions. When they use UAVs, they generally control them directly through the ground control center, forming a star-shaped structure model with multiple UAVs as rays starting from the ground station command center. According to relevant reports, the main communication mode of THE US unmanned aerial vehicles (UAVs) in service is still the communication mode controlled by the ground control center. The ground control center controls the UAV as follows:

1. Direct remote control of one or several UNMANNED aerial vehicles (UAVs), which is widely used but limited by ground curvature and limited communication distance of UAVs;

2. Indirectly through a number of unmanned aerial vehicles as relay, using them to achieve the control of remote unmanned aerial vehicles and information transmission. The communication range of UAVs can be extended to a great extent by using the method of UAV group formation networking and multi-hop communication.

UAV formation flight is aligning unmanned aerial vehicle (UAV) according to certain rules, and then in the process of the flight between the unmanned aerial vehicle (UAV) is able to keep a certain distance, avoid collisions, the key lies in between the UAV formation keeping, path planning, so the ground station and the data link between the more drones and ground station for UAV control management became the focus of our research content.

4.Routing protocol design

The nodes in the WIRELESS AD hoc network communicate with each other through multi-hop wireless links. The network has no fixed infrastructure, such as base stations. Each node in the network can act as a router to forward data to other nodes. Developing a dynamic routing protocol that can effectively find routing between nodes becomes the key to wireless AD hoc network design. Therefore, this routing protocol needs to be able to achieve the following functions:

Can sense the change of network topology. Because wireless AD hoc networks require multi-hop communication, routing protocols must ensure strong connectivity of links in the path. A node in a wireless AD hoc network must know its surroundings and the nodes with which it can communicate directly. There are two ways to provide network connection in WIRELESS AD hoc networks: planar routing network structure and hierarchical routing network structure. In a planar routing network, all nodes are level, and packet routing is based on peer-to-peer connections. However, in the hierarchical routing structure, at least one node at the lower level should be the gateway to the higher level.

Maintain network topology connections. Because the relative position of each node can change at any time, the network topology changes frequently. In order to maintain strong connectivity between nodes, routing protocols must dynamically update link states and reconfigure themselves [3].

If the routing algorithm of central control is adopted, it will consume too much time and energy to transmit the change of link state to all nodes. Therefore, a fully distributed intelligent routing algorithm should be adopted.

Highly adaptive routing. Compared with static nodes in wired networks, wireless AD hoc networks require a highly adaptive routing mechanism to handle fast topology changes. Traditional routing protocols, such as distance vector and link-state algorithm, require a large amount of routing information to be exchanged between designated routers, so they cannot work effectively in wireless AD hoc networks. Therefore, according to the characteristics of wireless AD hoc network, a new routing algorithm is proposed. Generally speaking, these routing algorithms can be divided into three types: table-driven algorithm, demand-driven algorithm, table-driven algorithm and demand-driven algorithm hybrid algorithm. Table-driven routing protocol USES periodic packet routing to exchange routing information, and each node maintains routing to all nodes in the whole network. Demand-driven routing protocol is the routing discovery process on demand based on the needs of sending nodes, and the network topology and routing table contents are also established on demand, so their contents may only be a part of the whole network topology information.

5.Time frame design

Reasonable time frame design is an important link to ensure system performance. In order to meet the complex data transmission requirements of uav self-organizing network and distributed TDMA mode, this section carries out an overall design of the system's time frame structure. Unmanned aerial vehicle (uav) self-organized Network communication Network model based on Clustering is a structural system, system will run into a cluster algorithm (Clustering) first running clusters, then according to the wheel (Round) running cycle in time, each cycle including time synchronization (SYNCg-Positioning), Network Management, Network Management), Distributed scheduling (Distributed Schedu-ling) and send data through a phase.

6.MAC scheduling mode

MAC design is one of the key technologies of wireless network. TDMA is an access control method that divides the sending time of each member according

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to time slices. It divides the time axis into moving length and repeating time frames, which eliminates collisions and reduces the energy consumption of nodes. In this paper, a distributed TDMA protocol is adopted as the MAC scheduling method of UAV network.

For different modes of UAV network, corresponding scheduling methods will be different. Due to the simple structure of peer mode of full connectivity, all nodes are peer structures and contain the same MAC. Therefore, it is only necessary to allocate corresponding time slot to each node in the traditional TDMA mode. For the clustering classification mode, MAC scheduling is divided into two parts: inter-cluster scheduling and intra-cluster scheduling.

7.Relay technology

When the UAV exceeds the radio coverage of the ground control station, the communication between the UAV and the ground control station needs to be achieved by means of relay. Relay mode can be divided into ground relay and air relay according to the location of the relay equipment. The ground relay forwarding equipment is located on the commanding height between the ground control station and the UAV, while the air relay adopts the uav relay forwarding or satellite relay forwarding. Compared with the two relay methods, the air relay costs more. Uavs relay mode adopts UAVs as relay and forwarding equipment, and consists of ground stations, relay UAVs and mission UAVs. It is characterized by fast moving speed, high mobility, low airwaves limited by space and low cost, but needs to strengthen the destruction resistance of relay UAV. Satellite relay adopts communication satellite as the forwarding equipment. Compared with UAV relay, satellite relay has a wider coverage, stable performance of satellite channel, wide available bandwidth and larger communication capacity, but it costs more.

8.Communication antenna design

Omnidirectional antenna is simple in structure, easy to meet the characteristics of uav node high-speed movement, adapt to the complex requirements of UAV application environment, and can ensure the stability of antenna gain, as well as the design of tracking device is relatively simple.

Directional antenna has the characteristics of high gain and low side lobe, and has the advantages of high spatial multiplexing, long transmission distance, high transmission rate, low interception and low detection.

The data link of UAV should combine omni-directional antenna and directional antenna to give full play to their advantages and increase the performance of physical layer, so as to further improve the network communication performance of UAV.

Antenna alignment means that the main beam of two antennas covers each other to achieve the maximum antenna gain. Antenna tracking is the use of antenna tracking equipment and algorithm, when the position of both sides of communication changes relative to each other, the antenna is always aimed at each other, to reduce external interference and inter-machine interference.

At the initial stage of network initialization, omnidirectional antenna is needed to search and find the location of neighbor nodes and topology information of the network due to incomplete topology information. Based on the node position information obtained by omnidirectional antenna, the directional antenna can be scanned quickly in a small area to achieve the antenna alignment effect and obtain the maximum antenna gain. The pitch Angle, swing Angle, attitude correction and other parameter information are added into the antenna alignment and tracking algorithm to obtain better performance and ensure the antenna alignment status of the communication dual transmission.

9.Conclusion

Through the research of uav self-organizing network in many aspects, Mu Wen puts forward a new architecture and management mode, and carries out a detailed design, which provides certain reference for the development of UAV technology in the direction of clustering, intelligence and network.

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