Structure Design for Unmanned Aircraft Traffic Management System

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***Abstract*—**The application of the Unmanned Aircraft System (UAS) in various fields has been attracting attention, and the development of a service utilizing UAS has been proceeding. With the increase in the number of Unmanned Aerial Vehicles (UAVs) and the increase in the scale of UAS networks, the role of management system for safety of UAS in the public airspace is becoming more important. Due to this safety issue of UAS, many project are currently underway to manage UAS traffic in various countries. This UAV traffic management system is called UAS Traffic Management (UTM) system, and Korea is also conducting a national project to build Korean UTM system. In this paper, we design the structure for UTM system implementation and define required functions for security and safety. In addition, we define the message to operate essential functions in the proposed UTM structure and design message flow between entities. Finally, we show the demonstration scenario that has been verified by applying our designed UTM system to real environment.

Keywords—drone; platform; unmanned aerial vehicle; unmanned aircraft system; unmmaned aircraft system traffic management

I. Introduction

Recently, the number of drones for personal leisure as well as Unmanned Aerial Vehicles (UAVs) for military, commercial, agricultural, and disaster response is increasing rapidly. Generally, the architecture of UAS is formed by UAVs, also known as drones, that are equipped with wireless communication devices, Base Stations (BSs) or Access Points (APs) on the ground, and a Ground Control Station (GCS) that monitors the flight status UAVs. With the increase in the number of UAVs and the increase in the scale of UAS networks, the role of management system for safety of UAS in the airspace is becoming more important. The UAS Traffic Management (UTM) project has been started for stable UAS management, and research and development is currently underway in many countries to build a UTM system suitable for their environment. Global UTM System market anticipated to reach $3.62 Billion by 2026 [1]. The need for a UTM system depends on many factors, such as unprecedented unmanned aircraft growth in the airspace, interest in other governments and emerging regulations, etc.

The UTM system aims to identify traffic information such as the flight path and current location of all UAVs flying in the same public airspace. Therefore, if an individual or service providers want to fly in the public airspace within the UTM scheme, the operators must register UAVs and their flight plans in advance with the UTM server. After that, they can then fly from the UTM server after obtaining a flight clearance. This procedure is meaningful in preventing accidents by managing traffic of all UAVs flying in airspace.

In addition, the reason why the UAS is popular in various fields is that it can be remotely controlled and can be operated by attaching additional equipment or devices to the UAVs. In particular, the combination of the UAS and the wireless communication equipment has improved the quality and level of service in terms of scope and utilization in the UAS mission performance. Through the wireless communication, the UAVs can transmit the results of the mission such as photos and videos to the ground. In the GCS, it is possible to transfer missions to the UAVs not only in the visible area but also in the beyond visual line-of-sight (BVLOS) areas. In addition, by deploying a server that collects data and provides a visualization function in the system, it is possible to operate a plurality of UAVs at the same time, instead of one UAV.

In this paper, we describe the essential functions of the UTM architecture and analyze the message flow among the UTM server, operators, and UAVs to implement the UTM system. In addition, we describe the operation scenarios for the traffic control of multiple UAVs equipped with the LTE based wireless communication board which we developed for the UTM system, and describe the implementation and actual demonstration.

II. UTM Scenario

For the traffic management of all UAVs flying in public airspace, there are some essential functions that a UTM server must provide. First, UTM server should provide users and aircrafts registration and management functions. The operators who desire to fly their UAVs in the UTM airspace must register themselves and their UAVs with the UTM server in advance. Through the registration process, the UTM server has the authority to determine whether the operator who want to fly his/her UAVs in the UTM airspace is a user on the registration list and to give flight permission.

Second, the UTM server should provide flight path management function. When a registered operator wants to fly,

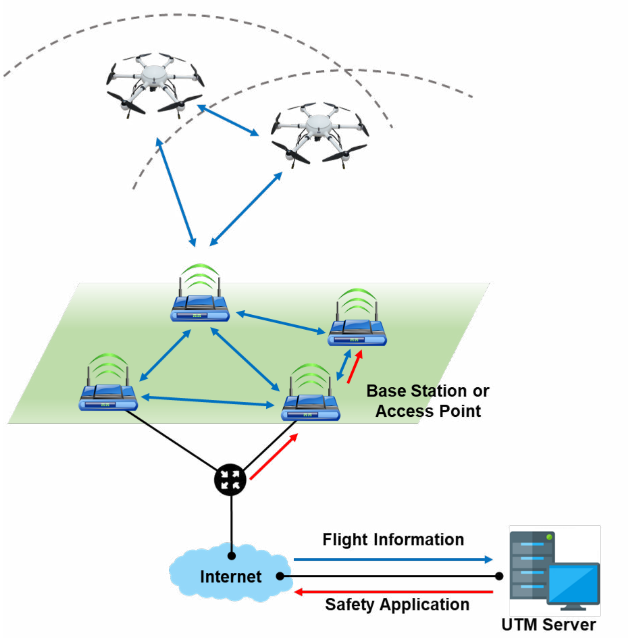

Fig. 1. Structure of UAS traffic management system

he or she must upload his flight plan to the UTM system in advance. The UTM server must determine the flight plan of all operators and configure the route to prevent accidents among UAVs flying in the same area at the same time.

Finally, the UTM server must continuously monitor the location and status of all UAVs in flight in the public airspace, and provide security enhancement functions that identify the UAVs as correct UAVs through mutual authentication and identification. This continuous observation function helps prevent accidents by monitoring the location of UAVs. This function can also be used to identify and take action against fraudulent registered falsified aircrafts.

III. DEMONSTRATION

In our demonstration, a total of four UAVs developed by different manufacturer were utilized. The FCC in each UAV includes Pixhawk-based controllers and a self-developed controller. Pixhawk is an independent open-hardware project that aims to provide the standard for readily-available, high-quality and low-cost autopilot hardware designs for the academic, hobby and developer communities. In the case of a UAV with Pixhawk-based FCC, data messages are sent to the UTM server via LTE according to the MAVLink (Micro Air Vehicle Link) message format. MAVLink is a protocol for communicating with small UAV. It is designed as a header-only message marshaling library. It is used mostly for communication between a GCS and UAVs and in the inter-communication of the subsystem of the vehicle. UTM server can analyze data messages by using MAVlink message library. On the other hand, in the case of the self-developed FCC, since the message format is developed in itself, the server needs an agent software to analyze the corresponding data messages.

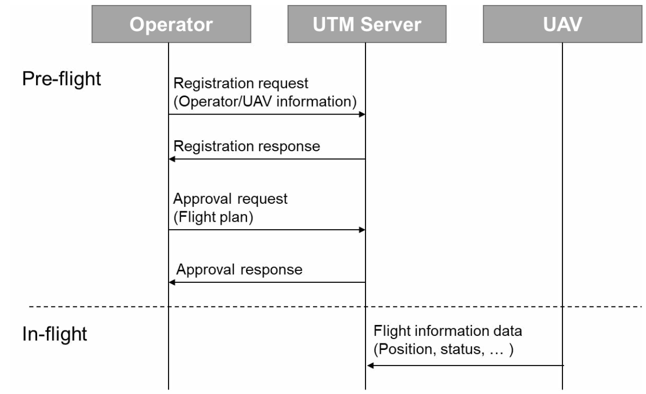

Fig. 2. Flow chart of UTM functions

We proposed a UTM system using LTE. In the case of cellular networks including LTE/LTE-A, it has wide coverage and high data rate, which makes them suitable for UTM system than any other communication system. There are policy issues such as authentication of the module itself for using licensed bands. We developed an LTE module applicable to UTM system through cooperation with mobile service provider of South Korea. Since commercial LTE networks are generally assigned dynamic IP addresses, it is necessary to have a server with a fixed IP address for LTE-based communication between UAV and GCS. Therefore, we developed GCS from global standard-based IoT platform which can manage and control the UAVs utilizing the system User Interface (UI).

The demonstration scenario is as follows: Users of different types of UAVs enter the flight route in advance in Yeongwol, Gangwon-do and wait for approval from UTM server. In Seoul, GCS confirms the real-time status of UAVs in Yeongwol. When all the UAVs are ready for flight, a manager orders takeoff and mission start at the same time via GCS. Upon receipt of the mission command message, each UAV performs a route flight along the flight path after takeoff. At this time, if a manager wants to fly the route through the real-time movement command instead of the pre-inputted route flight, drags the corresponding UAV on GCS and moves it to the desired position. The UAVs that have been flying all the way do hovering in the air and inform the GCS in Seoul that they are on standby by sending a status message. In Seoul, a manager checks all the UAVs' command termination status and issue the RTL command. Finally, the entire demonstration scenario ends with all the UAVs landing at their home positions.

IV. CONCLUSION

In our demonstration and design of UTM system, we proposed the essential functions of the UTM architecture and analyzed the message flow among the UTM server, operators, and UAVs to implement the UTM system. In addition, we described the operation scenarios for the traffic control of multiple UAVs equipped with the LTE based wireless communication board which we developed for the UTM system, and described the implementation and actual demonstration.

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