Standard Activities for Unmanned Aerial Systems

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Ofinno • ofinno.com • June 2020

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1. Introduction

In the modern lexicon, pilotless aircraft are known as "drones". In English, the term has long referred to male honeybees. Unlike worker bees, who gather nectar and pollen, a drone's only function is to mate with an unfertilized queen bee. According to military historian Steven Zaloga, the term has been applied to pilotless aircraft since 1935. Admiral William Standley of the United States Navy saw a demonstration of the Royal Navy's new remote-control aircraft, the DH 82B Queen Bee. This pilotless aircraft was controlled from the ground and used for target practice. Adm. Standley charged Commander Delmer Fahrney with developing something similar for the U.S. Navy. In homage to the Queen Bee, Fahrney adopted the name 'drone' to refer to these aircraft.

The first drones, comprising a kite, a balloon, and a camera, date back to the 1800s. For a long time, drones were used mainly for military purposes. Now, drones are also popularly used by hobbyists, and many companies are preparing for commercial usage of drones (for example, air delivery).

Unmanned Aerial Vehicle (UAV) is a more formal term for drones. An Unmanned Aerial System (UAS) may refer to the entire system needed to operate the UAV. The UAS includes the UAV itself, a ground control system, a camera, a positioning system, all the software and skills needed to operate the UAS, and tools required for maintenance. Wireless communication, which enables the ground control system to communicate with the UAV is a core component of the UAS. For Beyond Line of Sight (BLOS) or other long-range operations, a cellular communication system may be necessary. Third

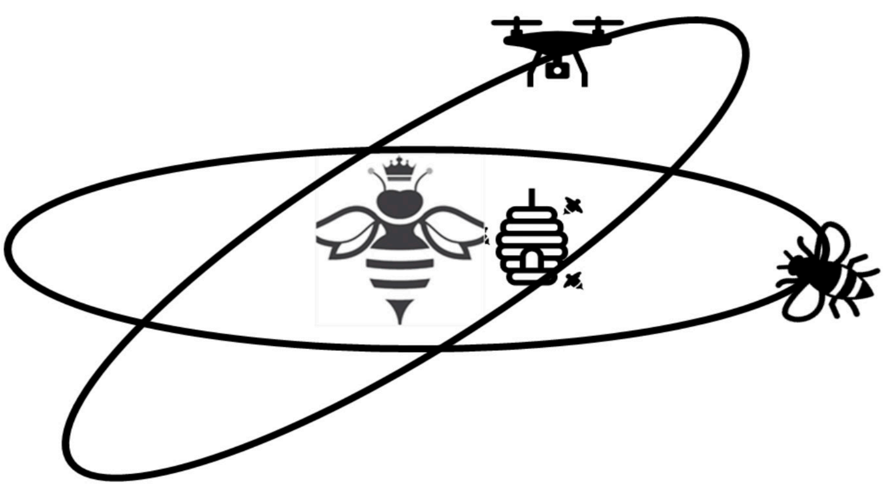

FIG. 1 Origin of term drone

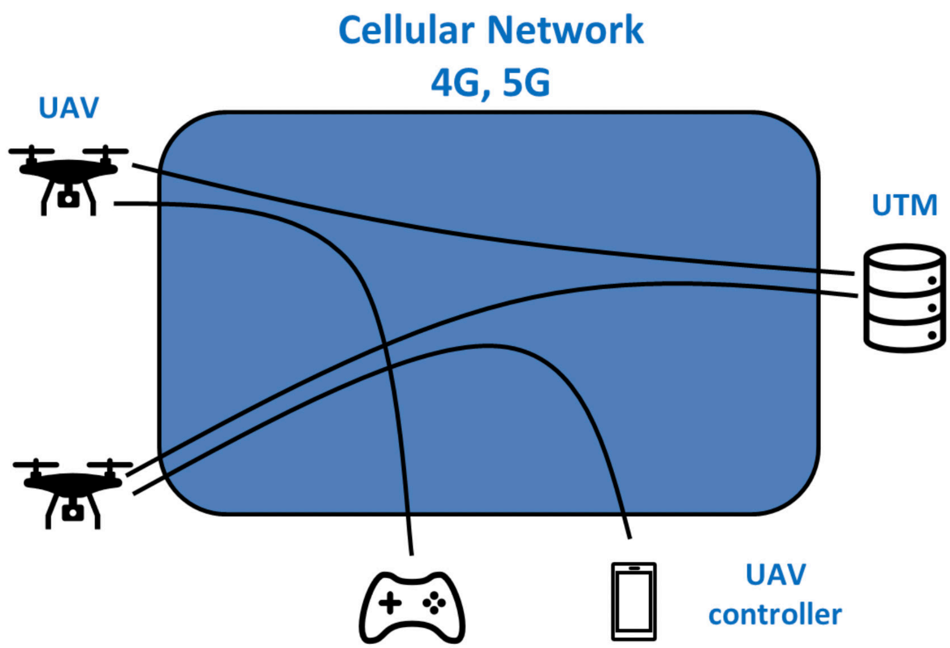

FIG. 2 Unmanned Aerial System

Generation Partnership Project (3GPP) systems offer excellent benefits for UAS operation by providing high reliability, QoS, robust security, and seamless mobility. This paper will address 3GPP Release 15 enhancements for aerial User Equipment (UEs) and ongoing study progress for 3GPP Release 17.

2. 3GPP 4G enhancements for UAS

Planning for UAS began during the development of the 3GPP's Long Term Evolution (LTE) standards. During the study for Release 15 (TR 36.777), interference caused by Aerial UEs was identified as a major issue. When Aerial UEs are in flight, they may have a high likelihood of line of sight (LOS) propagation condition to multiple base stations. As a result, Aerial UEs can cause interference to more cells than a conventional UE. Accordingly, 3GPP sought to provide five functionalities to mitigate these interference issues.

A. Subscription-based Aerial UE identification and authorization

Whether a UE is allowed to use Aerial UE communication is stored in the user's subscription information in a Home Subscriber Server (HSS). The HSS transfers this subscription information to a Mobile Management Entity (MME) during attach and tracking area update procedures. The MME provides part of the subscription information to a base station. The base station provides the Aerial UE communication functionalities if the UE is allowed to use the Aerial UE communication.

B. Height-based reporting for Aerial UE communication

A UE may report a measurement result based on a measurement report configuration received from a serving base station. The measurement report configuration comprises events (e.g., serving cell threshold, neighbor cell threshold) for the measurement report. For Aerial UE communication, a new event "height" is added for the measurement report. The UE sends a height report when the altitude of the Aerial UE is above or below a threshold configured by the serving base station.

C. Interference detection and mitigation for Aerial UE communication

If received signaling power (e.g., RSRP) of multiple neighboring cells are above certain levels for a UE, the UE may experience or introduce interference. For interference detection, the serving base station may indicate to a UE a radio resource management (RRM) event that triggers a measurement report when the individual (per cell) RSRP values for a configured number of cells fulfill the event. The measurement report contains RRM results and location if configured. For interference mitigation, the service base station may indicate to a UE with a dedicated UE specific alpha parameter for physical uplink shared channel (PUSCH) power control.

D. Flight path information reporting

A serving base station may request a UE to report flight path information consisting of a number of waypoints defined as 3D locations. The report can consist also include timestamps per waypoint. Base stations can use the waypoints of the UEs for congestion prediction and resource handling to mitigate interference issues.

E. Location information reporting, including UE's horizontal and vertical velocity

An Aerial UE may be configured to report location information, including horizontal and vertical speed. Location information can be included in an RRM report and/or a height report.

3. Remote Identification (RID) technology

One of the main topics for the UAS from a regulation point of view is safety and security. For example, a collision between manned aircraft and UAV may result in casualties. Falling drones may cause human injury on the ground. To prevent such accidents in the United States, the Federal Aviation Authority (FAA) is attempting to integrate drones into the National Airspace System (NAS) by introducing Remote Identification (RID). RID is the ability of a UAS in flight to provide identification & tracking information that can be received by other parties and will play a vital role in identifying and grounding unauthorized UAV in restricted areas. The FAA is gathering information for the implementation of RID. UAVs above 0.55 lbs may be mandated to support RID.

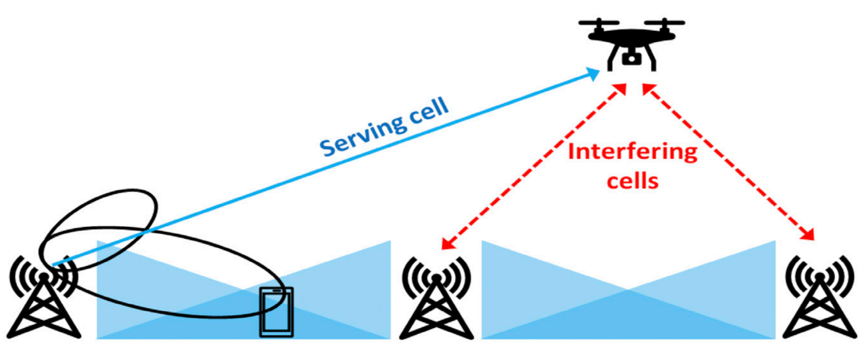

FIG. 3 Unmanned Aerial System

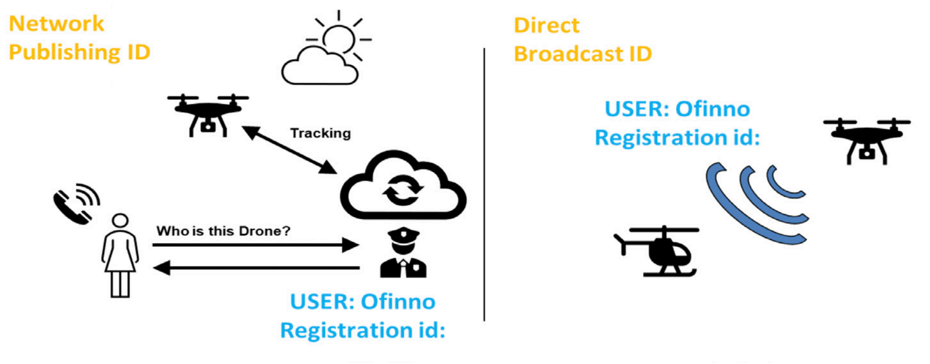

FIG. 4 Two types of Remote Identification (RID)

There are two types of RID: Standard RID and Limited RID. For Standard RID, a UAV must support a Network Publishing ID and a Direct Broadcast ID. For Limited RID, the UAV only needs to support the Network Publishing ID. The Network Publishing ID is based on communication via the internet from an RID server provider that interfaces with the UAV. The Direct Broadcast ID is based on direct transmission of the RID by a UAV using its onboard Bluetooth or Wi-Fi module. A UAV that only supports Limited RID is not allowed to fly above 400 feet and network connectivity is required for flight. A UAS that supports Standard RID is allowed to fly above 400 feet and there is no restriction for the network connectivity.

4. 3GPP 5G enhancement for UAS

Current standard activity for UAS (as of May 2020) is targeting Release 17. Services and System Aspects Working Group 1 (SA WG1) has completed an architecture requirement for UAS regarding Command & Control (C2) communication. There are three types of C2 communication: Direct C2 communication, Network-assisted C2 communication, and Unmanned Aerial System Traffic Management (UTM) navigated C2 communication.

For Direct C2 communication, the UAV and UAV controller establish direct C2 links to each other. For Network-assisted C2 communication, a UAV controller is connected to the 3GPP network and communicates with the UAV via a 3GPP network. For UTM-navigated C2 communication, a UAV is provided with a pre-scheduled flight plan (e.g., an array of 4G polygons for autonomous flying). The UTM maintains a C2 communication link to the UAV controller in order to regularly monitor the flight status of the UAV and/or verify the flight status with up-to-date dynamic flight information.

SA Working Group 6, dedicated to 3GPP applications, studies potential impacts of UAS on the application layer. For example, this working group studies the application enabler functionalities for UTM and the service interactions between UAS and the UTM for fly route authorization, location management, and group communication support.

SA Working Group 2 has started a study item to address RID requirements to maximize the opportunity for mobile networks to develop business serving UAVs. So far, SA WG2 defined seven key issues for UAS connectivity, identification, and tracking (TR 23.754): (1) UAV identification, (2) UAV authorization by UTM, (3) UAV controller identification and authorization/authentication, (4) UAV and UAV Controller tracking, (5) UAV authorization revocation and reauthorization failures, (6) UAV Controller and UAV association, and (7) User Plane Connectivity for UAVs. The first, second and seventh issues are described below.

The first key issue, UAV identification, is directly related to the RID requirement. SA WG2 will discuss what identities are associated with and how they are to be used by a UAV and/or a UAV controller in the 3GPP system. SA WG2 will also discuss what identities are exchanged with parties outside the 3GPP system to enable the 3GPP system to provide support for UAV authorization, authentication, identification, and tracking of UAVs. The identity may be an existing 3GPP identity or new identity for the UAV.

The second key issue, UAV authorization by UTM, relates to solutions on how the UAVs are authorized for operation in the 3GPP system. In particular, these solutions enable UAV tracking and identification once the UAV is authorized for flight by the UTM. For example, the 3GPP system may assist a flight path authorization with the UTM to avoid the UAV flying through an out of coverage area of the mobile network.

The seventh key issue, UAV authorization revocation and reauthorization failures, relates to handling failed authorization, reauthorization, or revocation of authorization by the UTM, considering the handling of UAV connectivity with UAV Controller and expected UAV behavior.

5. Conclusion

The realization of RID will accelerate commercial UAV services such as drone delivery, and drone surveillance. The 5G 3GPP system will be a key communication system for successful UAS operations. NR enhancements will be primarily based on the work of SA Working Groups 2 and 6.

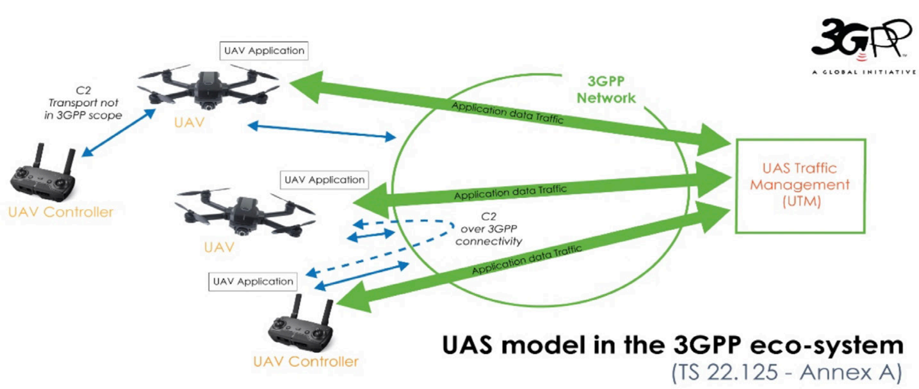

FIG. 5 UAS model in the 3GPP eco-system

6. Acronyms

3GPP: 3rd Generation Partnership Project
4G: 4'th Generation
5G: 5'th Generation
BLOS: Beyond Line-of-Sight
C2: Command & Control
FAA: Federal Aviation Administration
HSS: Home Subscriber Server
LOS: Line of Sight
LTE: Long Term Evolution
MME: Mobile Management Entity
NAS: Non-Access Stratum
PUSCH: Physical Uplink Shared Channel
RID: Remote Identification
RRM: Radio Resource Management
RSRP: Reference Signal Received Power
SA: System Architecture
TR: Technical Report
UAS: Unmanned Aerial System
UAV: Unmanned Aerial Vehicle
UE: User Equipment
UTM: Unmanned Aircraft System Traffic Management
WG: Working Group

7. References

1) The Flight of 'Drone' From Bees to Planes, Ben Zimmer.
2) X. Lin et al., "The Sky Is Not the Limit: LTE for Unmanned Aerial Vehicles," in IEEE Communications Magazine, vol. 56, no. 4, pp. 204–210, April 2018.
3) 3GPP Technical Report 36.777, "Study on Enhanced LTE Support for Aerial Vehicles"
4) 3GPP Technical Specification 36.300, "Evolved Universal Terrestrial Radio Access and Evolved Universal Terrestrial Radio Access Network"
5) 3GPP Technical Report 23.754, "Study on supporting Unmanned Aerial Systems (UAS) connectivity, Identification and tracking," January. 2020.
6) https://www.3gpp.org/uas-uav

About the Author:

Jinsook is an inventor of 89 US patents and more than 150 pending patents. Prior to joining Ofinno she was a 3GPP SA2 delegate, contributing to cellular system architecture enhancements for IoT as well as access and mobility management architecture for 4G and 5G systems. At LG Electronics, Jinsook was a team leader for GERAN standards and played a key role in the development of a modem chip set for base station/mobile GSM/GPRS/WCDMA. She is a freethinker who is inspired by the knowledge that her inventions help people by creating practical solutions for advanced cellular systems.

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