Chapter 6

Internet of Drones–Enabled Smart Cities

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ABSTRACT

Unmanned aerial vehicles (UAVs) are expected to provide data service to users as aerial base stations, as gateways to collect the data from various sensors, and as sensor-mounted aerial platforms deployed in smart cities. The study in this chapter initially starts with the air-to-ground (A2G) channel model. Due to the unavailability of channel parameters for UAVs at low altitudes, measurements were performed using a radio propagation simulator for generalized environments developed using ITU-R parameters. Further, cell coverage analysis is shown with simulation results obtained from the ray tracing. Later, an optimal replacement to UDNs was proposed to support the flash crowds and smart cities known as ultra-dense cloud drone network. This system is advantageous as it offers reduction in total cost of ownership due to its on-demand capability. Further, work is shown on implementing parameters for 5G physical layer with generalized frequency division multiplexing modulation over A2G channel on the UAV network to provide reliable and faster connectivity for ground users and sensors.

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INTRODUCTION

With challenges faced by today’s cities in terms of sustainable growth and development, many cities tend to invest in research and innovation of Information and Communication Technology (ICT) and developing policies towards improving quality of life and sustainability. Internet-of-Things (IoT) can achieve this by creating and accessing bulks of data from the vast number of sensors and create new applications or services by post-processing of the data in the servers, thus creating an intelligent society and cleaner environment leading to smart cities (Ahlgren, 2016). IoT aims at enabling all the physical devices to be connected anytime, anywhere ideally to a centralized network and to provide any service, where the devices are equipped with a variety of sensors to offer different services. Further, interestingly from a technological perspective, Unmanned Aerial Vehicles (UAVs), commonly known as drones, can be integrated into the IoT infrastructure as Internet-of-Drones (IoD) in two possible ways as shown in Fig. 1:

1. **UAVs sensor nodes**: The UAVs equipped with a variety of sensors have the possibility to hover or fly over the required airspace, where data collection is needed from the environment. For example, air quality monitoring, temperature monitoring, precision agriculture, wildlife monitoring and remote sensing, etc. This data can be easily transmitted to the E-UTRAN Node B (eNodeB) or Long Term Evolution (LTE) base station.

2. **UAV relays**: UAVs can also be equipped with gateways, where data from various sensors or ground users can be aggregated and relayed to the nearest base station to be sent over the cloud server, where post-processing of the data can be done. This is useful mainly for scenarios such as smart hospitals, homes, industries, fleet management and health monitoring of swarm of vehicles where a large amount of data is collected from various sensors and can be easily transmitted to an LTE network via offloading to the UAV relay.

Such operations can be easily performed by UAVs due to their utmost capacity of hovering and flying close to the users and sensor mounted devices, which leads to an efficient and optimized way of data collection, aggregation and offloading, in case of heavy traffic of data from various use cases.

The contributions of this chapter mainly include the introduction to UAV based IoT platforms (Motlagh, 2017), known as IoD, equipped with different sensors and gateways depending on the use case.

![Figure 1. UAV architecture for IoT operations](image-url)