Joint Sensing and Communication for Enabling Advance Air Mobility

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Abstract

Throughout the world, the aviation industry is enthusiastically moving toward the introduction of Unmanned Aircraft System (UAS) services, including the delivery of goods in urban regions. Rural regions also need advanced air mobility (AAM) and UAS services with applications to health and smart agriculture. However, progress in this direction is much slower than expected. The use cases of AAM include applications such as transportation of emergency medical supplies, perishable farm goods, transportation of critical patients, surveillance, providing cellular connectivity, etc. All these applications are critical to basic human needs and AAM can play a crucial role in some of the life-threatening and critical situations. In this paper, we particularly focus on addressing the challenges of communication and networking for enabling AAM.

CCS Concepts

• Networks → Application layer protocols; **Network resources allocation**; **• Hardware → Digital signal processing**.

Keywords

Advance Air Mobility, Joint Sensing and Communications, Spectrum Allocation, Testbed Design

1 Introduction

The worldwide aviation industry is enthusiastically embracing Unmanned Aircraft System (UAS) Traffic Management (UTM) and Urban / Advanced Air Mobility (UAM/AAM) services [7]. Rural regions need AAM and UTM services equally as applications such as Internet connectivity, medical services, and smart agriculture [2]. The global agriculture drone market in 2024 is estimated to be $4.98 billion and expected to reach $18.64 billion by 2028, with a compound annual growth rate of 14.1% [1]. Smart agriculture is expected to become pervasive, leading to agricultural drones becoming commonplace in the skies in rural areas over the next decade. In developing countries, transportation, as well as broadband connectivity services, is poor. Due to a lack of proper infrastructure, the rural populace is often deprived of even the basic healthcare. In such cases, unmanned aerial systems can play a critical role by aiding in the transportation of medicines, commodities, providing Internet services and more so transport people.

Advancements in technology at multiple levels are essential to enable AAM. In particular, from the communications and networking perspective, we highlight the need for joint sensing and communications, access and backhaul, and a rigorous testing of the developed technologies via a large testbed. The next section details some of the innovations required to enable AAM.

2 Key Research Directions

2.1 Joint Sensing and Communication

When multiple unmanned aerial vehicles move autonomously, it is important to have intelligence within them to avoid collisions between themselves and with the surrounding obstacles/objects/air hazards [4]. To avoid collisions and integrate intelligence into UASs, an intelligent environment awareness system is required. Thus, a sensing mechanism similar to radars is essential for safe AAM operations.

The upcoming concept of joint sensing and communication enables sensing and communications to be carried out simultaneously using the same waveform [6]. Having separate systems for sensing and communication increases the bulkiness of the system and requires more energy and resources. Both are not acceptable for UASs because of limited onboard energy storage. We refer to such a system as joint sensing and communication (JSC), meaning that a common waveform from a single transmitter is used to communicate and also detect nearby objects/obstacles/air hazards. The development of novel JSC waveforms specific to AAM operation is required.

2.2 Access and Backhaul

Connectivity is primarily a spectrum-deficient operation problem. Although connectivity via satellite can be achieved, until now, such usage is prohibitive due to high cost and narrow spectrum. To enable AAM, we must focus on the problem of making sufficient bandwidth available to the mission-critical AAM services for safe operations. Mission-critical communications may require ultra-low latency and reliable communication. Thus, the magnitude of spectrum available is key to its successful realization.

There are various ways of making the spectrum available for the AAM operations such as making use of cognitive radios in different bands, backhaul from LEO satellites, high altitude platforms and terrestrial networks, making space in the current frequency spectrum allocations for AAM operations, etc. [3].

2.3 Testbed Design

A large testbed is required to test out some of the systems developed. Just like to operate an aircraft requires sufficient testing of every possible situation in a real-life environment, a similar test is required for AAM to make sure that they do not cause any unwanted hazards [5]. The design of the testbed and the emulation of critical situations is essential for the successful implementation of AAM systems.

3 Conclusion

AAMs are set to bring a revolutionary change in how we transport people, goods, and services. To enable AAM requires meticulous development of communication and sensing mechanism. To enable JSC requires a robust spectrum management and a comprehensive testbed to make sure that the system works in all possible situations.

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