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Review

Integration of Cognitive Radio Technology with unmanned aerial vehicles: Issues, opportunities, and future research challenges

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ABSTRACT

Unmanned aerial vehicles have gained much popularity for applications which do not require human operator or are too dangerous for human operators. They operate on IEEE L-Band, IEEE S-Band and ISM band. However, with recent advances in technology, new wireless devices have been developed which also operate on these bands. Therefore, these bands have become overcrowded and unmanned aerial vehicles may face the problem of spectrum scarcity. Moreover, there are specific challenges associated with aeronautical communication links. Cognitive radio has emerged as a promising solution for solving the challenges caused by scarce spectrum. We focus on the integration of unmanned aerial vehicles with cognitive radio technology. Our main objective is to highlight and discuss some of the issues, challenges, and future research challenges associated with the integration of unmanned aerial vehicles and cognitive radio technology which occur as a result of the intrinsic characteristics of unmanned aerial vehicles or cognitive radio technology.

Contents

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1. Introduction

Unmanned aerial vehicles (UAVs) or Drones are airplanes which operate without human pilots and are gaining popularity in military, private and public sectors due to their versatility and their use in a wide range of applications. They are gaining more popularity among applications which do not require human operator or where human intervention is risky, dangerous, impossible or expensive. Examples of such applications include traffic monitoring (Kafi et al., 2013; Puri, 2005; Srinivasan et al., 2004), tracking and surveillance (Jaimes et al., 2008; Kota and Jamshidi, 2008), military operations (Glade, 2000), wilderness search and rescue (Adams et al., 2009), commercial drones (Villasenor, 2014), disaster recovery (Tuna et al., 2014), hazardous material recovery, fire control and many others. UAVs were initially designed for surveillance and reconnaissance purposes. They are equipped with sensors, cameras and communications equipment. A UAV can also equipped with weapons for attacking purposes and such a UAV is called unmanned combat aerial vehicle (UCAV) (Washburn and Kress, 2009). UAVs vary in size, capabilities, design, energy and flying range. Normally, small and lightweight UAVs with limited flying range and energy are used in close-range surveillance such as infantry battalions, while larger and heavier UAVs with high flying range and more energy are used for longer reconnaissance purposes such as operational-level intelligence (Washburn and Kress, 2009).

Unmanned aerial vehicles operate on IEEE S-Band, IEEE L-Band and on Industrial, Scientific and Medical (ISM) band (Jain and Templin, 2012). It is worth mentioning that different wireless networks (such as WiFi, Bluetooth, IEEE 802.15.4 networks) coexist in the environment where UAVs operate. Furthermore, with technological advances, there is a drastic increase in the development and usage of new devices for wireless and cellular networks which operate in these bands leading to increased utilization of these bands. UAVs also face the problem of spectrum scarcity. In order to address this problem, cognitive radio technology (CRT) emerges as a promising solution by using dynamic spectrum access technique for the opportunistic utilization of licensed and/or unlicensed spectrum bands. CRT enables UAVs to exploit licensed or unlicensed spectrum band opportunistically. Thus, UAVs can carry on their operations by operating on licensed spectrum bands without interfering with licensed users known as primary users (PUs).

The motivation of this work is to consider the problem of spectrum scarcity, faced by UAVs with the objective of highlighting issues, challenges and future directions for the realization of integration of CRT with UAVs. In this paper, we discuss the need of CRT for UAVs and present some potential applications of CRT based UAVs with illustrative examples. The main contribution of this paper is the discussion over issues, challenges and future directions for the integration of CRT with UAVs.

The organization of this paper is as follows: in Sections 2 and 3, we give an overview of CRT and UAVs, respectively. In Section 4, we highlight the need of CRT for UAVs and describe the advantages, which UAVs can get from CRT. In Section 5, we discuss potential applications of CRT based UAVs. Integration issues of CRT based UAV and future research challenges are discussed in Section 6. Finally, Section 7 concludes the paper.

2. Overview of cognitive radio technology

In the early 1990s, large portions of spectrum were available and there was no problem of spectrum scarcity. Therefore, wireless networks followed fixed spectrum assignment policy. But over the years, a large portion of spectrum was assigned to licensed users and at the same time we have witnessed significant advances in wireless technologies and devices such as smartphones (e.g., iPhone, Android, Windows Phone), tablets, iPADs, PDAs as well as the emergence of a wide range of applications. This fixed spectrum assignment coupled with advances in wireless