Chapter 21
Cognitive Radio Networks: A Comprehensive Review

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ABSTRACT

The radio spectrum is witnessing a major paradigm shift from fixed spectrum assignment policy to the dynamic spectrum access, which will completely change the way radio spectrum is managed. This step is required to greatly reduce the load on limited spectrum resources, which is being enforced by the exponential growth of wireless services. This is only feasible due to the capabilities of the cognitive radio, which will provide a new paradigm in wireless communication by exploiting the existing unused spectrum bands opportunistically. The chapter provides insight into recent developments in the area of cognitive radio networks with the main focus on review of the spectrum management, which consists of four main challenges: sensing of selected spectrum band, decision about sensed spectrum, sharing of spectrum among many users, and spectrum handoff. Further, sharing of target channel after a channel handoff is analyzed using game theory to get a different perspective on the existing medium access techniques.

INTRODUCTION

Radio spectrum plays a major role in vital technological innovations in wireless communications, but it is also very important for the economic growth of a country *(Bhattarai, Park, Gao, Bian, & Lehr, 2016)*.With the advent of various emerging wireless products, the usage of limited spectrum has grown exponentially in the recent years. *Zhou et al.(2017)* stated in their work that in the next few years, it is expected that global mobile data traffic will grow up to 49 EB/ month, which is nearly a seven times increase over year 2016. *Kumar et al. (2018)* reveals the trend in growth of mobile data traffic as shown in Figure 1.

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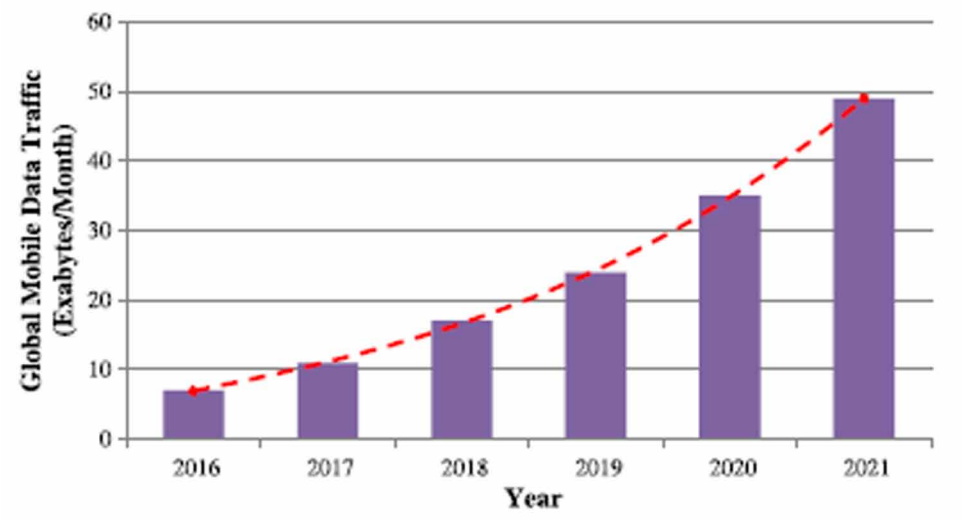
Figure 1. Trend in growth of mobile data traffic



Therefore, it will become extremely difficult to satisfy the ever increasing demand through the current fixed spectrum assignment policy in which spectrum band is exclusively used for the particular applications and it has also led to under-utilization of a significant portion of the spectrum (like TV bands). It is almost impractical to find new frequency spectrum bands from the already in adequate spectrum resources to improve overall system capacity. To tackle the above challenges, a paradigm change is required in which spectrum is shared with more flexibility and dynamically among all categories of users. *(Federal Communications Commission [FCC], 2003)* has proposed to enable any unlicensed user to use the licensed frequency band such that no interference to the primary license holders is ensured. The solution to this problem is implemented by the use of cognitive radio by making dynamic spectrum access possible *(Kumar, Dhurandher, & Woungang, 2018)*. Further, an eminent example of wireless standard that benefits from the recent developments in the area of cognitive radio is the IEEE 802.22 Wireless Regional Area Networks standard. In the rest of the chapter, an introduction to the cognitive radio networks, their application and then wireless regional area networks is provided in detail followed by game theoretic analysis of post handoff target channel sharing by the SUs. The last section draws the conclusion.

COGNITIVE RADIO

The concept of cognitive radio was proposed by (*Mitola, 2000)*. Cognitive radio techniques present the ability to utilize or share the spectrum band in an opportunistic manner. The under-utilization of spectrum is described in cognitive radio networks as a spectrum hole (*Haykin, 2005)*.As shown in Figure 2 (*Akyildiz et al.,2009)*, a spectrum hole is a band of frequencies which is assigned to a licensed user, but, not being utilized by that user at a particular time and specific geographic location.

Cognitive radio is the technology that enables the efficient use of spectrum holes. *Akyildiz et al. (2006)* formally define the cognitive radio as follows: