Chapter 1

Introductory Chapter

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1. Cognitive radio challenge

One of the most critical resources required for wireless communication is the radio spectrum. One can see the radio spectrum as nonrenewable natural resource. If a part of spectrum has been used for some application, one cannot simultaneously reuse it at the same place for some other application. National and international laws and agreements regulate spectrum usage so that the services provided were free from interference caused by other users. Traditionally, the administration of the spectrum rights tends to grant exclusive rights to some services in the major geographic regions. For instance, in the United States and many other countries, the frequency band 535–1605 kHz is allocated for AM radio, 54–72 MHz for TV channels 2–4, 88–108 MHz for FM radio, and so on. This static allocation has over the years led to many successful applications, but it has also resulted in a situation where almost all the available spectrum has been assigned to specific applications and there is no room for emerging services.

On the other hand, several studies and measurement campaigns are showing that the spectrum is actually underutilized. Spectrum utilization depends on frequency, geographical location and time. Fixed spectrum allocation, however, prevents the rarely used frequency bands being reused. These studies suggest that new devices should use the underutilized spectrum in an opportunistic manner. It leads to the core idea behind cognitive radio, i.e., the radio that is aware of the environment and can adapt the transmissions according to the interference it sees. In other words, the cognitive radio seeks the unutilized frequencies and uses them for its own transmissions in an adaptive manner. The concept of cognitive radio was first proposed by Joseph Mitola III in a seminar at the Royal Institute of Technology in Stockholm in 1998 and published in an article by Mitola and Maguire in 1999 [1]. Since then, there has been a lot of work on the concept some of which is printed in this volume.

Cognitive radio is an adaptive, intelligent radio, and network technology that can automatically detect available channels in a wireless spectrum and change transmission parameters, enabling more communications to be performed concurrently. Cognitive radio is based on software radio technology where the pieces of software have replaced traditional hardware components such as amplifiers, modulators, and mixers. This way it is easy to change the operation of the radio. All that is needed is reprogramming. It can also be considered to be an adaptive radio, which monitors and modifies its own performance.

The cognitive radio needs to collect cognition about the radio environment to operate efficiently. Such a radio needs to understand if the spectrum it intends to use is free or utilized by some primary user and redistribute the available spectrum dynamically. By primary user, we mean the licensed user of the band, and correspondingly, the cognitive radios are often termed as secondary users. This process is called spectrum sensing.

A secondary user may collect information about primary user activities alone or it may cooperate with other secondary users to improve the detection and estimation results. Of course for the cooperation to be possible, several secondary users must be designed so that they allow it. If cooperation between the secondary users is possible, it results in more reliable detection. This is because cooperation allows overbridging the fading and shadowing effects that are present in real-world radio propagation by the usage of spatial diversity, which in turn improves the results.

The first standard on cognitive radio was developed by IEEE (IEEE 802.22) and published in 2011. The standard combines a database of licensed users of the area with spectrum sensing to locate the primary users. The standard was developed for usage of unused television channels in the rural areas.

The chapters of this book discuss different aspects of cognitive radio, covering a large span of the problems that have to be solved in order to build reliable systems. This is the hope of the editor that the material published in this book is useful for people who design the cognitive radio systems and for the people who research the different aspects of the exiting subject.

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References

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