Chapter 7
Architecture of Cognitive Radio Networks

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ABSTRACT

Today's wireless networks are characterized by fixed spectrum assignment policy. The spectral scarcity and the inefficiency in the spectrum usage necessitate a new communication paradigm to exploit the existing wireless spectrum, opportunistically. Cognitive Radio (CR) is that very paradigm for wireless communication, in which either a network or a wireless node reconfigures its transmission or reception parameters to communicate efficiently avoiding interference with licensed or unlicensed users. CR adapts itself to the newer environment on the basis of its intelligent sensing and captures the best available spectrum to meet user communication requirements. When the radio link features are extended to the network layer, the cognitive radios form the cognitive radio network. This book chapter is focused on cognitive radio network, architecture of the CR, and its relevance in the wireless and mobile Ad Hoc networks.

INTRODUCTION

Wireless spectrum, which is a costly resource, is currently characterized by a Static Spectrum Allocation (SSA) policy, where governmental agencies assign wireless spectrum to license holders on a long term basis for large geographical regions. In recent days with the huge hike in spectrum demand, SSA policy faces spectrum scarcity in particular bands. In contrast, regulatory bodies in various countries (including the Federal Communications Commission in the United States, and Ofcom in the United Kingdom) have found that most of the radio frequency spectrum (FCC, 2003) is inefficiently utilized. For example, cellular network bands are overloaded in most parts of the world, but amateur radio and paging frequencies are not. SSA policy prevents rarely used frequencies (those assigned to specific services) from being used by unlicensed users, even when their transmissions would not interfere at all with the assigned service. This was the reason for allowing unlicensed users to utilize licensed bands...
whenever it would not cause any interference. This paradigm for wireless communication is known as Cognitive Radio (CR). In other words, CR is the key enabling technology of Dynamic Spectrum Access (DSA) policy which provides the capability to share the wireless channel with licensed users in an opportunistic manner. CR networks are envisioned to provide high bandwidth to mobile users via heterogeneous wireless architectures and DSA techniques. More specifically, the CR technology will enable the users (1) to determine which portions of the spectrum is available and detect the presence of licensed users when a user operates in a licensed band (Spectrum Sensing), (2) select the best available channel (Spectrum Management), (3) coordinate access to this channel with other users (Spectrum Sharing), and (4) vacate the channel when a licensed user is detected (Spectrum Mobility) (Akyildiz, 2006).

The purpose of this chapter is to provide a clear conception of modern day technology to its readers. It was written keeping in mind the needs of the undergraduate and postgraduate students of Electronics and Communication Engineering, Electrical Engineering, Computer Science and Information technology of different universities. Further, it also serves the needs of the researchers as well as professionals working in the areas of mobile communication, wireless ad hoc networks and cognitive radio. Moreover, it also satisfies the thirst for knowledge general readers, if any, who is interested to work on these topics. This book chapter explains the importance and necessity of the costly radio spectrum and its limitations with respect to its proper utilization. Readers of this chapter will get a concept of the spectrum management, modern day technology like the CR, its architecture and working principle, details of the Cognitive Radio network (CRN), and spectrum mobility. Learning objectives of the book chapter can be categorized as follows:

- Role of spectrum in wireless network.
- Embedding of intelligence within a device and the evolution of the Cognitive Radio.
- Different types of the Cognitive Radio Networks.
- Spectrum sensing, decision and mobility in the Cognitive Radio Network.

BACKGROUND OF COGNITIVE RADIO

In the history of the communication system, invention of the radio communication is considered to be a milestone. Radio communication means the transmission of the signals through the free space. Research for such wireless communication started many years ago and many individuals have contributed to this research.

As per available records, a Scottish scientist namely James clerk Maxwell, first showed mathematically the propagation of the electromagnetic waves through the free space (1862). Later the same theory was shown by a German scientist Heinrich Ruolf Hertz (1884). That radio signals can be sent without wire was shown by Professor Oliver Lodge and Alexander Muirhead (1884). An Indian scientist Acharya Jagadish Chandra Bose demonstrated the use of the radio waves (1894). Sir Bose proved that signals can be sent even distant apart without wires. An Italian Scientist Gugielmo Marconi first transmitted signals across the Atlantic Ocean from Cornwall to Newfoundland. For his revolutionary invention Marconi got patent in radio communication (1900, Patent No 7777). He is often known as the inventor of radio who got the Nobel Prize in 1909. New history in the field of radio and wireless communication started since then.

Wireless communication is solely dependent on the electromagnetic spectrum but the availability of this electromagnetic spectrum is complex and costly. Huge money is spent for these processes. Different Government agencies at International and National level like International Telecommunication Union (ITU), Office of Communication