Chapter 7
Co-Evolutionary Analysis of Cognitive Radio Systems

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ABSTRACT

Cognitive radio technology is commonly seen as a promise to form the basis of the next largest breakthrough in the development of ubiquitous wireless broadband services. However, the disruptive nature and complexity of this technology raises a host of associated issues, including the open question on reasons for the slow progression of the innovation. In this chapter, the authors offer a co-evolutionary analysis of the CR innovation context, aiming to reveal a stakeholders’ domain, which is best positioned to lead the further CR development. Having analysed the position of CR within technology, market, and regulatory domains, the authors come to conclude that the regulatory domain oversees some of the most crucial enabling factors that may decide the future of CR technology.

1. INTRODUCTION

The concept of Software Defined Radio (SDR) – a radio system in which RF emissions and operational parameters could be defined and re-configured by software – has been discussed since mid 80-ties with the first commercial products arriving to the market in the early 90-ties (Kloch et al., 2009). In 1999 Mitola and Maguire (1999) introduced the concept of Cognitive Radio (CR) – a kind of an application built on top of the SDR technological base to enable “intelligent” on-the-fly self-reconfiguration of the radio system to adapt to the instantaneous state of the spectrum-space environment as well as to real-time user requirements.

As a technology innovation, CR was conceived as a promise to overcome the limitations of the existing international governance system for radio spectrum allocation, under which the key resource of wireless communications systems – the radio spectrum – is rigidly divided into chunks (bands), and the bands are strictly associated with specific applications. The “intelligent” re-configuration...
feature of CR might allow dissociating specific bands from specific technologies/applications, thus boosting overall efficiency of spectrum use. More specifically, the possibility to dynamically access the underutilized chunks of spectrum, known as “white spaces”, would allow accessing opportunistically the bands that would be otherwise considered closed for access by new spectrum users. This paradigm is referred to as “Opportunistic Spectrum Access” or “Dynamic Spectrum Access” (DSA).

More than a decade down the road since the concepts of CR and DSA were proposed, the SDR-based radio systems remain mostly restricted to the narrow niches of heavy-duty high-end infrastructure devices such as tactically agile military equipment and complex (multi-standard) base stations of cellular telephony systems that utilize re-configurability in order to become more easily adapted to evolving radio interface specifications by simple software upgrades. Meanwhile, the true CR still remains the subject of the R&D efforts and only few commercially oriented pilots have been deployed on a very limited geographical scale.

The pattern of CR development does not fit easily into popular theoretical frameworks on technology innovation – the niche technology so far hasn’t found its way to the broader market.

As of today, it seems that nascent CR industry is disoriented by apparent failure of initial DSA vision to make quick progress to market and as a result it is increasingly unclear where the impetus for the CR innovation and commercialization advancement should come from. To find out which domain or stakeholder is better positioned to take the lead in formulating the vision, requirements and coordinating standardization work, we conduct a co-evolutionary analysis of the heterogeneous context in which the CR develops.

2. ONE PHENOMENON, MANY PERSPECTIVES: CR THROUGH THE PRISM OF TECHNOLOGY INNOVATION

2.1 The Phenomenon of CR

The term ‘cognitive’ in CR refers to the distinctive – intelligent – features of the radio system, namely its ability to derive real-time information about its local radio environment, analyse this within the context of its own technical capabilities, applicable regulatory policy rules as well as user communications requirements and based on that analysis make autonomous decisions on the best possible way to configure itself for carrying out the communications task at hand (Doyle, 2009). It is postulated that by carrying out this autonomous and environmentally conscious adaptive operation, the CR would be able to make the most optimal use of available radio frequency resources and installed network infrastructure and thus ensure highly reliable anywhere-anytime communications (Haykin, 2005).

CR was meant to start off a new disruptive development cycle in wireless telecommunications industry – a global behemoth in economic and technological terms. Contemporary developments in that industry find their roots in the policy, technology, and market developments of the 1980s. It may be therefore worth to take a short digress to review some of the lessons learned over those years.

Since the 1984 European Council’s (EC) Recommendation 84/549/EC, which aimed to “stop the fragmentation of the European market, to help users to have cheap prices, and to help the European industry to have a wide market”, as well as 1987 and 1990 EC’s Green Papers outlining a