AN OVERVIEW OF TECHNICAL ASPECT FOR COGNITIVE RADIO NETWORK TECHNOLOGY

1Awanish kumar kaushik, 2Manorma Kaushik, 3Anubhav kumar, 4Sweta Kaushik

1, 2, 3Electronics and Telecommunication Dept
Vishveshwarya Group of Institutions
Dadri, Gr.Noida, India
Awanishkaushik@gmail.com
Manorma_kaushik@yahoo.com
Rajput.anubhav@gmail.com

4Department of Master in Computer Application
Institute of Management & Education, Ghaziabad, India
Swetakaushik01@gmail.com

ABSTRACT
Cognitive radios have become a great deal of attention in the past years. Wireless communication technology is the primary objective to improve the quality of service for the end entity. Cognitive radio is a technology capable of advancing wireless communications. Cognitive radio techniques are applied to many different communications systems. They are for increasing utilization of radio frequencies that are wasted today, allowing the improved commercial data services, and allowing for new emergency and military communications services [1]. For example, these techniques are being considered by the U.S. Today Cognitive Radio Technology are being included by many standards such as WiFi (IEEE 802.11), Zigbee (IEEE 802.15.4), and WiMAX (IEEE 802.16). More advances are occurring in a rapid way. IEEE 802.22 is the first cognitive radio-based international standard. The cognitive radio, made on a software-defined radio, is an intelligent wireless communication system, is aware of its environment and uses the methodology of understanding- by-building to learn from the environment and being adapted to statistical changes in the input, with two primary objectives that is highly reliable communication whenever and wherever needed and efficient utilization of the radio spectrum. The purpose of this paper is to explain an Architecture and design for cognitive radio terminals that can be used to make rapidly deployable wireless communication applications.

Keywords: Cognitive Radio, adaptability, configurability, Spectrum sensing.

I. INTRODUCTION
The need for higher data rates is increasing due to the transition from voice communications to multimedia applications. By giving the limitations of the natural frequency spectrum the current frequency allocation schemes can not fulfill the requirement of higher data rate devices that are increasing. Cognitive radio (CR) was first defined as a technology that is preferred for high-end applications in the military when the general CR concept had emerged [2]. Cognitive radio is a tempting solution to the spectral congestion problem by introducing opportunistic usage of the frequency bands that are not heavily occupied by licensed users [3], [4]. In this paper, we use the definition given by Federal Communications Commission (FCC): “Cognitive radio: A radio or system that senses its operational electromagnetic environment and can dynamically and autonomously adjust its radio operating parameters to change system operation, such as maximize throughput, reduce the interference, facilitate interoperability, access secondary markets.” [4].

Cognitive radio is the new way of researching about wireless communications. Indeed, it is considered as one of the key candidate system for the fourth-generation (4G) wireless technology. Some domains, such as the Federal Communications Commission (FCC) in the United States are considering the use of CR technologies [5, 6]. A great deal of efforts is putting into cognitive radio technology, is scattered across many activities. Many standardization organizations such as the Software-Defined Radio
(SDR) Forum and International Telecommunications Union-Radio Sector (ITU-R) are working in this area [7].

Two essential features, characterize cognitive radio technology based on SDR namely configurability and adaptability. Configurability has an ability to switch between different communications modes and Adaptability has the ability to select the appropriate communication mode based on wireless channel conditions in order to maintain predefined operation constraints as bit error rates, power consumption, and interference levels. Higher layer and protocol design studies have been addressed [8]-[10]. In [11]-[12], a specific gateway is used to bridge between IEEE 1394 devices [11] or to interconnect WiFi and ZigBee network [12].

The mental states and processes are described by computational view of cognition:

1) Mental states and processes intervene between input stimuli and output responses.
2) The mental states and processes are described by algorithms.
3) The mental states and processes lend themselves to scientific investigations.

III. COGNITIVE RADIO COMPONENTS

High-level view of the components that can be found in a cognitive radio system is provided by the figure 1. There must be at least one reconfigurable radio component with parameters, such as operating frequency and bandwidth, although many more parameters may exist [25]. The system determines what behavior is acceptable in what circumstances. This database can be configurable which allows the policy changes. The system must have a reasoning engine that can accept inputs from the sensing engine and a policy database that determines an appropriate configuration for the radio components [26], [27]. The reasoning engine is capable of learning based on experience. The current configuration of the radio components is maintained by a configuration database. A simple CR system may have a reconfigurable radio component which accepts the sensing information from a single local node. By IEEE, an area known as coexistence, is related to cognitive radio, has been considered for many years. Many radios has an ability to coexist with other radios using different protocols in the same bands. An unlicensed band where a wide
A variety of unrelated protocols are applied includes IEEE standards such as IEEE 802.11, IEEE 802.15, and IEEE 802.16. The coexistence techniques developed for these bands are similar to those for DSA. In some regards, the application of CR/DSA techniques can be thought of as an evolution of coexistence techniques [28-29].

Fig. 1 A view of the components that may exist in a cognitive radio system

IV. COGNITIVE RADIO ARCHITECTURE

The proposed cognitive radio architecture consists of three sub-systems, as shown in Fig. 2:

1) Configurable digital transceiver
2) Channel monitoring and spectrum sensing module
3) Communication management and control

The communication management sub-system uses spectrum sensing module to adjust the operation parameters in the RF front end and digital transceiver. The configurability of cognitive radio is governed by the design of the configurable digital transceiver, and adaptability is maintained by the second and third subsystems.

Architecture for a rapidly deployable radio network using software defined radio techniques was presented in [30]. The mobility was limited due to the size of the software radio system. The Recent advancement in semiconductors and other enabling technologies have made it feasible to build small form factor software radios using different computing devices [31]-[33]. The flexibility and inter-operability of software radio systems are managed by different architectures, e.g. software Communication Architecture (SCA) [34]. The digital wireless transceiver consists of a chain of function blocks which is described by physical layer specifications of their wireless standard, i.e., sampling rate and modulation. Each is broken into a combination of digital signal processing blocks, such as filters, signal transforms, and logical and arithmetic operations [35].

Fig. 2 Cognitive radio architecture

The parameters (input) of the digital transceivers identify the operational blocks in the signal processing chain. The digital wireless transceiver typically encompasses a chain of function blocks described by physical layer specifications of their wireless standard, i.e., sampling rate, modulation, and coding scheme [36]. Filters, signal transforms, and logical and arithmetic operations are broken into a combination of digital signal processing blocks.

The parameters (output) of the configurable transceiver are maintained by cognitive radio e.g. BER and the power level. The wide arrows in Fig 2 indicate the high speed data paths. One path exists from the digital transceiver to monitor to perform spectrum sensing activities on the raw digitized data received. Another path is found between the digital transceiver and input-output devices between the digital transceiver and communication management and control sub-system. The communication management and control sub-system performs several key tasks in the cognitive radio design [37].

The design is divided between DSP and FPGA in the following ways. The DSP is for communication, control and packet handling tasks. The digital signal processing operations such as filtering and up/down conversion are performed in FPGA. The part of the digital transceiver is made in the DSP, whereas most of the digital transceiver design and the complete spectrum sensing are implemented in FPGA. The communication monitoring is maintained in DSP.
V. COGNITIVE RADIO COMMUNICATION LINK

The basic communications architecture is assumed by all the applications shown in Fig. 3. This architecture explains the simplex link between a source and a destination. The source radio has a cognitive engine which controls the source radio’s parameters, and uses the existing link to exchange configuration information (e.g., modulation scheme, frequency, or bandwidth) and statistics (e.g., noise power or bit error rate).

For this system to work, we assume that both the master and slave radio ends with the same initial configuration. When the cognitive radio decides to alter the configuration the master SR sends a message to the slave using configuration. A simple example of this would be a frequency hopping radio system where a hop to frequency $f_i$ is signaled by sending a control message at frequency $f_i$. To extend this basic architecture to a duplex link between two SRs, a cognitive radio engine is added to the second radio. However, here we assume that each cognitive engine works as an independent agent controlling only outbound data and not communicating with other cognitive radio engines [38-39].

![Fig. 3 Configuration of a basic simplex cognitive radio communications link](image)

Fig. 3 Configuration of a basic simplex cognitive radio communications link

To extend this model to a multiparty or ad-hoc network, each radio maintains independent state in its cognitive radio engine for each destination node. These channels are not completely independent so some shared state can be used to more quickly to find optimal solutions.

VI. COGNITIVE RADIO CYCLE

A cognitive radio looks to software-defined radio to perform this task. For other tasks of a cognitive radio, the cognitive radio seems to process the signal and machine-learning procedures to be implemented. The cognitive process starts with the passive sensing of RF stimuli and happens with action. In this paper, we focus on three on-line cognitive tasks [13-14]:

1) Radio-scene analysis, which consists the following:
   - Estimation of interference temperature of the radio environment;
   - Detection of spectrum holes.

2) Channel identification, which encompasses the following:
   - Estimation of channel-state information (CSI);
   - Prediction of channel capacity for use by the transmitter.

3) Transmit-power control and dynamic spectrum management.

Tasks 1 and 2 are carried out in the receiver, and task 3 is carried out in the transmitter. Through interaction with the RF environment, these three tasks form a cognitive cycle [15] which is pictured in its most basic form in Fig. 4.

![Fig. 4 Basic cognitive cycle. (The figure focuses on three fundamental cognitive tasks.)](image)

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It is necessary that the cognitive mode in the transmitter must work in a harmonious manner with the cognitive modules in the receiver. To maintain this between the cognitive radio’s transmitter and receiver at all times, we need a feedback channel connecting the receiver to the transmitter. Through the feedback channel, the receiver is enabled to convey information on the performance of the forward link to the transmitter. The cognitive radio is, therefore, by necessity, an example of a feedback communication system [40-42].
A broadly defined cognitive radio technology accommodates a scale of differing degrees of cognition. At one end of the scale, the user may simply pick a spectrum hole and make its cognitive cycle around that hole. At the other end, the user may employ multiple implementation technologies to build its cognitive cycle around a wideband spectrum hole or set of narrowband spectrum holes to provide the best expected performance in terms of spectrum management and transmit-power control.

VII. CONCLUSION

Since the introduction of cognitive radio in 1999 [43], there have been many high-level discussions on proposed capabilities of cognitive radios. Cognitive radio technology is advancing in a very fast way. Standardization is the key to the current and future success of cognitive radio. This paper proposed an overview of Technical aspect for Cognitive Radio networks technology by focusing on the basic overview and architecture design. Cognitive Radio networks technology play equally important roles in the future of wireless networks. Cognitive Radio networks technology is very necessary as it recommends a whole new dimension of market opportunities. This presents the use of cognitive radio technology to rapidly deploy a network between heterogeneous wireless terminals. The work shows the design procedure and implementation details of the building blocks for a cognitive radio system is capable of connecting a scattered and incompatible set of wireless terminals. It decays the cost of operation and opens new business opportunities in local area deployments.

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