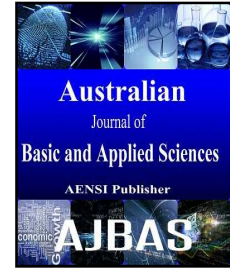




ISSN:1991-8178

Australian Journal of Basic and Applied Sciences

Journal home page: www.ajbasweb.com



Cognitive Radio Network Application to Disaster Recovery Using Software Defined Radio

Ramasamy Mariappan

Department of Electronics & Communication Engineering Sri Venkateswara College of Engineering, India

ARTICLE INFO

Article history:

Received 10 October 2015

Accepted 30 November 2015

Available online 24 December 2015

Keywords:

Cognitive radio, disaster recovery, spectrum sensing, software defined radio network

ABSTRACT

Application of cognitive radios as the wireless terminals in ad hoc networks in emergency situations has distinct advantages. Better bandwidth, interoperability, avoidance of interference, and ant-jamming capabilities are a few such advantages. This paper deals with ad hoc networks incorporated with cognitive radios, which acts as wireless terminals, that can be used in emergency situations and can be referred to as Emergency Cognitive Radio Ad Hoc Networks (Emergency CRAHNs). In this paper, we propose the collaborative spectrum sensing methodology using Cognitive Collaborators where multiple cognitive radios operate together such that reliability of spectrum sensing is improved. This proposed system plays a vital role during disaster management. In disaster management situations, the networks usually depend on public networks such as GSM & GPRS. These public networks are likely to get overloaded resulting spectral bandwidth limitations to the multimedia applications and also in worst cases cause denial of service. Usage of cognitive radios in emergency situations has the potential of alleviating the spectrum shortage problem by dynamically accessing free spectrum resources. Such CRAHNs provide flexibility in terms of frequency of operation of the ad hoc network. Cognitive Radio improves the spectrum utilization when there is a congestion or failure of certain existing technologies at times of emergency and disaster, this new technology can be used to meet the user's needs. This paper proposes a prototype model with software defined radio (SDR) technology. The network-centric cognitive radio architecture under consideration in this paper is aimed at providing a high-performance platform for experimentation with various adaptive wireless network protocols ranging from simple etiquettes to more complex ad-hoc collaboration.

© 2015 AENSI Publisher All rights reserved.

To Cite This Article: Ramasamy Mariappan, Cognitive Radio Network Application to Disaster Recovery Using Software Defined Radio. *Aust. J. Basic & Appl. Sci.*, 9(35): 116-121, 2015

INTRODUCTION

An important aspect of the cognitive radio platform is its ability to opportunistically use portions of the spectrum that are not being used, which requires the ability to efficiently scan spectrum usage. Furthermore, it is very important to detect and identify types of interference that the platform is facing. This becomes increasingly difficult for arbitrary radio systems. Thus we can

focus on an OFDM radio platform because it allows a simple characterization of interference in terms of the OFDM subcarriers. Software defined radio, does however, require the implementation of several hardware components. The general layout of the SDR is shown below, in figure 1. In general, the first two blocks of each path and the antenna make up the hardware side of the SDR and the third block is the computer/software.



Fig. 1: Software Defined Radio Network.

Corresponding Author: Ramasamy Mariappan, Department of Electronics & Communication Engineering Sri Venkateswara College of Engineering, India
E-mail: prof.mariappan.r@svcolleges.edu.in

A paper on spectrum detection algorithms was carried out in order to understand the computational complexity and response times for the scanning receiver. In order to solve this detection and estimation problem, we used an eigenvalue decomposition of the sample covariance matrix of the received signal. This analysis was performed using computer simulations for two common sources of interference: a microwave oven and a Bluetooth radio. *F. Akyildiz et al* in their paper “Cognitive radio ad hoc networks: research challenges, to appear in *Ad Hoc Networks*”, Journal, Elsevier, 2009 describes the capability of the infrastructure-based cognitive networks is contrasted to the infrastructure-less cognitive networks. The paper clearly shows the lack of coordination and cooperation in the infrastructure-less cognitive networks. Local observation in conjunction with node cooperation is proposed. The nodes sense their local environments and cooperate in sensing and information sharing. However, mobility poses a challenge to sensing and information sharing. A scheme, which addresses cooperative sensing, information sharing and mobility, is desired. During disaster and emergency conditions traditional communication facilities get impaired but it is important to have communication between all the first responders. In such situations wireless technologies offer a suitable way for communication. The emergency communications and disaster relief works create high traffic load and which in turn leads to congestion also network capacity and coverage are the major drawbacks of traditional wireless technologies. As it is known that the spectrum is partitioned and allocated for different purposes, not all the spectrum is used in particular space or time and the unused spectrum can serve the demand in need. “Cognitive radio” which is an intelligent wireless communication system can find spectrum holes (unused spectrum bands) and uses them for communication there by facilitating the effective use of spectrum.

II. Proposed Work:

In disaster management situations, the networks usually depend on public networks such as GSM & GPRS. These public networks are likely to get overloaded resulting spectral bandwidth limitations to the multimedia applications and also in worst cases cause denial of service. Usage of cognitive radios in emergency situations has the potential of alleviating the spectrum shortage problem by dynamically accessing free spectrum resources. Such Cognitive radio ad hoc networks (CRAHNS) provide flexibility in terms of frequency of operation of the ad hoc network. Cognitive Radios (CRs) based on Software Defined Radios (SDR) by definition are able to work in different frequency bands and support multimedia services such as voice, data, and video. Particular emphasis has been placed on high performance in a networked environment where each node may be required to carry out high throughput packet forwarding functions between multiple physical layers. Key design objectives for the

cognitive radio platform include:

- multi-band operation, fast frequency scanning and agility;
- software-defined modem including waveforms such as DSSS/QPSK and OFDM operating at speeds up to 50 Mbps;
- packet processor capable of ad-hoc packet routing with aggregate throughput ~100 Mbps;
- spectrum policy processor that implements etiquette protocols and algorithms for dynamic spectrum sharing.

The cognitive radio prototype’s architecture is based on four major elements: (1) MEMS-based tri-band agile RF front-end, (2) FPGA-based software defined radio (SDR); (3) FPGA-based packet processing engine; and (4) embedded CPU core for control and management. 5) Disaster management module with CRHANS. These components will be integrated into a single prototype board which leverages an SDR implementation

III. Implementation:

3.1. Software Defined Radio using USRP:

The cognitive radio is a concept which is widely accepted and various research work in CR is adapted in newer technologies like LTE, 802.11ac and 802.22. Software defined radio radio setup with facilities to experiment and understand the already established principles and concepts of cognitive radio. With the help of Software Defined Radio platforms is it possible to be updated with research work in CR concepts. The Universal Software Radio Peripheral (USRP 2) is the hardware solution for GNU Radio. The USRP 2 and GNU radio setup will be used in Ubuntu, a Linux based operating system. Each USRP consists of a motherboard that contains a digital-to-analog converter (DAC), analog-to-digital converter (ADC), SRAM, gate-field programmable gate array (FPGA) and a gigabit Ethernet interface. The major components of USRP2 are listed as follows Radio frequency (RF) front-end is implemented on the daughterboard. There are a variety of daughterboards that are available to work at different frequency band. The RF front end translates the range of frequencies at the receiving end to a lower range at its output. The opposite occurs for the transmitting side, where the RF front end translates the range of frequencies to the final higher frequency range.

1. ADCs and DACs are the bridge between the continuous analog signals and the discrete digital samples. All the ADCs and DACs are connected to the FPGA. The functionality of the FPGA is to perform the high-speed general purpose operations, such as digital-up conversion and digital-down conversion, decimation, and interpolation, and to reduce the data rate feeding to the gigabit Ethernet connection. This connects the FPGA to the computer, where all of the waveform specific processing is performed on the host computer.

2. Python is a dynamic object-oriented programming language that has been proven to have strong integration capabilities with other languages.

It is simple to use and offers much more structure and support for large programs than shell scripts could offer.

3.2. Cognitive Radio Network Lab:

The Cognitive Radio Network Research Lab would require the following hardware, Software and other networking accessories.

A. The platform should support most of the open source communities for eg., GNU radio, open BTS etc., The Cognitive radio hardware should have a wide frequency range of operation. Some of the high level specification for the radio is as below

B. Cognitive Radio lab is visualized to be comprising of several software defined radio platforms with variable processing powers. The processing requirement for each technology may differ. As the SDR is used for the research purposes easy programmability of the SDR is important criteria.

C. Synchronization capability to external accurate clock references is an important requirement hence the lab will have clock sources and SDRs should be capable of taking the inputs from the clock source. In order to realize multi antenna MIMO or set up a small base station network the GPS plays important role.

D. The Cognitive Research lab will have capability to test both in wired and wireless conditions. It is important to have the right accessories for these tests.

E. In order to cover the simulation tests for spectrum sensing and hand over using the CR concepts controlled fading of the radio signals are important. Generally the RF faders that are capable of simulating the power, delay of multipath profile and Doppler. These faders available in the market are quite expensive in the order of upto 1 crores. As an alternative we consider most of the CR related experiments can be done with a digitally controlled attenuator which can modify power profile. We would require to use CR RF signal fader with 4 ports to realize the same.

F. The intention of the setup lab is to get the facility to both student and faculty, where in they have access to latest technology like LTE. As we consider LTE is one of the important technology defining the 4th and 5th Generation wireless networks (4G and 5G), we intend to procure below software stacks object licenses as part of the lab. Here the idea is to enable the lab with necessary software licenses with good control on the interfaces. The software can be used for improving or developing certain algorithms which can enable discovery of novel ideas and result in paper publication on 4G/5G technology trends.

G. Network Equipment and computers:

Networking protocols and networking components are inherent part of the CR lab to realize IP network and gateways. There needs to be investments on switches, linux based servers and computers to realize various components of the network

3. Radio frequency (RF) front-end is implemented on the daughterboard. There are a variety of daughterboards that are available to work at different frequency band. The RF front end translates the range of frequencies at the receiving end to a lower range at its output. The opposite occurs for the transmitting side, where the RF front end translates the range of frequencies to the final higher frequency range

4. ADCs and DACs are the bridge between the continuous analog signals and the discrete digital samples. All the ADCs and DACs are connected to the FPGA. The functionality of the FPGA is to perform the high-speed general purpose operations, such as digital-up conversion and digital-down conversion, decimation, and interpolation, and to reduce the data rate feeding to the gigabit Ethernet connection. This connects the FPGA to the computer, where all of the waveform specific processing is performed on the host computer.

5. Python is a dynamic object-oriented programming language that has been proven to have strong integration capabilities with other languages. It is simple to use and offers much more structure and support for large programs than shell scripts could offer. Python is available on Windows, Mac OS, and Linux operating systems. In the GNU software radio platform, all the signal processing blocks are written in C++, which are then connected by Python.

3.3. Adaptive Network Protocols: CSCC Common Spectrum Coordination Channel:

In parallel to SDR and packet processor design work described above, we are implementing the concept of an adaptive wireless network bootstrapped from the Common Spectrum Coordination Channel (CSCC) etiquette protocol previously developed at WINLAB. The CSCC protocol (which uses a broadcast beacon mechanism to inform neighboring radios of signal properties) is being extended to include information necessary for self-organization into a collaborative network of cognitive radios. Information on transmit power, PHY speeds, channel quality and aggregated routing information is added to the beacon to facilitate self-organization. This concept is shown in Figure 2 below.

The 5GHz radio setup consists of the MAX2827EVKIT 5GHz transceiver, Kyocera TCXO crystal, Hittite HMC408LP3 power amplifier, Hittite HMC224MS8 switch and a Centurion WTS2450RP-SMA antenna. The MAX2827EVKIT transceiver IC supports single and dual-band operation between 2.4GHz to 2.5GHz and 5.15GHz to 5.35GHz. It has a receiver sensitivity of -75dBm at 54Mbps and is capable of operating at both 802.11g & 802.11a modes. The HMC408LP3 is a 5.1- 5.9 GHz high efficiency power amplifier that offers +30dBm P1dB. The amplifier provides 20dB of gain, +32.5dBm of saturated power, and 27%

PAE from a +5.0V supply voltage.

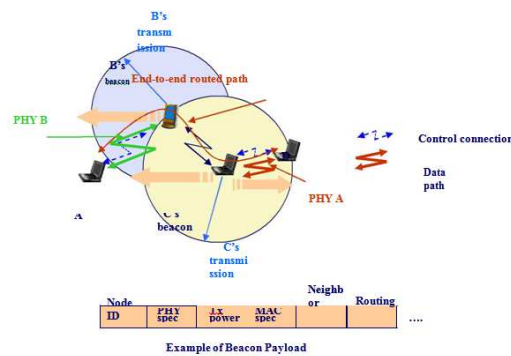


Fig. 2: Concept for CSCC-based self-organization in a cognitive radio network 5GHz SDR Setup.

Table I: summary of the features of the tri-band front-end platform.

	2.4GHz transceiver				5GHz transceiver				900MHz transceiver			
	MAX2825EVKIT				MAX2827EVKIT				ML2722 (VCO, PLL, image			
Transceiver	modulator, LNA, VCO, frequency				modulator, LNA, VCO, frequency				reject mixer, RF and IF and			
	synthesizer, baseband		and control		synthesizer, baseband		and control		baseband filters) and		ML2751	
	interface)				interface)				(Integrated LNA and PA)			
Power Amplifier	MAX2847EVKIT (P _{OUT} =24dBm)				Hittite HMC408LP3 (P _{OUT} =27dBm)				Included in ML2751			
	Hittite HMC484MS8G provides				Hittite HMC224MS8 provides				Skyworks AS214-92 provides switching between Transmit and receive signal path up to			
T/R Switch	switching between Transmit and receive signal paths up to 3GHz				switching between Transmit and receive signal paths in 5 to 6GHz.				3GHz. (IP _{1dB} = 27dBm, IL=0.4dB)			
	(IP _{1dB} = 40dBm, IL=0.8dB)				(IP _{1dB} = 33dBm, IL=1.2dB)							
Crystal Oscillator	Kyocera MFO-208F Provides a 40MHz frequency reference				Kyocera MFO-208F Provides a 40MHz frequency reference				Pletronics SW7745HV Provides a 6.144MHz frequency reference			
	Centurion dual-band WTS2450RP-SMA (2.5dB)				Centurion dual-band WTS2450RP-SMA (3.4dB)				Radial/Larsen SPDA24918			

Upon any channel congestion, a CRAHN can switch to other empty channels/frequencies on the basis of monitored channel information. Other advantages of usage of cognitive radios in military networks include interoperability among different services and legacy equipment. The use of dynamic spectrum management in future military CRAHNs is expected to improve service and increase the combat capability during the exercise and operation. Usage of cognitive radios in military networks includes interoperability among different services and legacy equipment. A cognitive collaborators (CC) model which improves network learning and facilitates information sharing is proposed. The model coordinates local spectrum sensing and facilitates information sharing. The scheme consists of static and dedicated sensing and information sharing nodes called cognitive collaborators. The cognitive collaborators acquire knowledge and share information. The scheme reduces false alarms and improves the efficiency of spectrum sensing. The cognitive collaborators are equipped with two radios, one to coordinate spectrum sensing and information sharing and the other for communication purposes. The network structure of the proposed scheme is illustrated in the following Figure. It incorporates a backbone of fully connected network

of cognitive collaborators equipped with two radios. The two radios of cognitive radios create two independent but connected networks, a sensing and data transmitting networks. The network is deployed within the ad hoc network of mesh clients. The network of cognitive collaborators is enclosed by blue lines in the Figure. The red section is a network of mesh routers; while the green is a network of mesh clients. The cognitive collaborators are networked to give a full coverage of the entire network and to effectively coordinate it. The network of sensing radios is designed for spectrum sensing. The cognitive collaborators through their sensing radios participate in local sensing and collaborate with local mesh clients within their communication ranges. They also share sensing information with other collaborators and mesh clients in availing global sensing information. The availability of global sensing information allows nodes to make correct spectrum decision and to allow nodes to sense and access the spectrum optimal and in an efficient manner. The optimal spectrum access and sensing improves end to end network throughput. The network of data transmitting radios is used for data communication. The use of two radios facilitates spectrum sensing and information sensing. Collaborators also

participate in general communication. The ability to communicate and sense the spectrum using two radios minimizes the spectrum sensing and information sharing overhead costs. The collaborators sense the spectrum, receive spectrum sensing information from nodes and broadcast it. The sensing information and the availability of spectrum holes in the network are shared in a distributed manner. The historic data on spectrum availability is

also availed to the entire network. The availability of historic and current data helps nodes to make proactive decisions to access the spectrum. It also minimizes the sensing time while maximizing transmission time. The scheme also improves the Primary Users detection accuracy and protects it from interference. The availability of sensing information is critical to spectrum sensing, spectrum decision and to Primary User protection

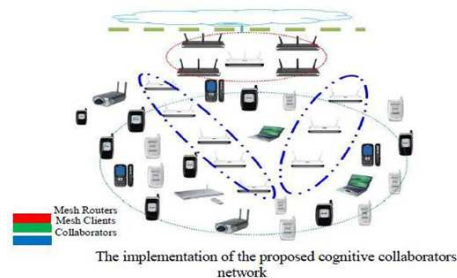


Fig. 3:

IV. Conclusion:

This paper proposes Software defined radio (SDR) hoc networks incorporated with cognitive radios, which acts as wireless terminals, that can be used in emergency situations like disaster management and can be referred to as Emergency Cognitive Radio Ad Hoc Networks (Emergency CRAHNs). In this paper, we propose the collaborative spectrum sensing methodology using cognitive collaborators where multiple cognitive radios operate together such that reliability of spectrum sensing is improved.

ACKNOWLEDGMENT

The authors would like to acknowledge our research committee for having done a preliminary review.

REFERENCES

Reconfigurable RFICs in Si-based technologies for a compact intelligent RF front-end Mukhopadhyay, R., Yunseo Park, Sen, P. Srirattana, N. Jongsoo Lee, Chang-Ho Lee, S. Nuttinck, , A. Joseph, J.D. Cressler, J. Laskar, 2005. Microwave Theory and Techniques, IEEE Transactions on, 53(1): 81 - 93

Novel multi-band broadband planar wire antennas for wireless communication handheld terminals Li, R.L.; DeJean, G.; Tentzeris, M.M., Laskar, J. Antennas and Propagation Society International Symposium, 2003. IEEE, 3: 22-27 Page(s): 44 – 47-3.

Josef Hausner, 2001. Integrated Circuits for Next Generation Wireless System European Solid-State Circuits Conference.

Linkopings University Programmable Baseband Processor Website
<http://www.da.isy.liu.se/research/bp/bbp1.html>

Cavallaro, J.R., M. Vaya, Viturbo: a reconfigurable architecture for Viterbi and turbo decoding; Proceedings of IEEE

International Conference on Acoustics, Speech, and Signal Processing, 2003. (ICASSP '03). 2: 6-10 Pages: II - 497-500

Eric Tell, Olle Segeroch, Dake Liu, 2003. A Converged Hardware Solution for FFT, DCT and Walsh Transform; Proc. of the International Symposium on Signal Processing and its Applications (ISSPA), Paris, France, I: 609 - 612

Eric Tell, Dake Liu, 2004. A Hardware Architecture for a Multi Mode Block Interleaver; International Conference on Circuits and Systems for Communications (ICCSC), Moscow, Russia.

Simon Leung, Adam Postula, Ahmed Hemani, 2000. Customized Reconfigurable Block-based Architecture for Baseband Data Processing in Telecommunication Applications. International Conference on Chip Design Automation (ICDA 2000), Beijing, China.

Sridhar Rajgopal, Joseph, R. Cavallaro, 2002. A Programmable Baseband Processor Design for Software Defined Radios. *IEEE Mid West Conference on Circuit and Systems*, Tulsa, USA.

Hui Zhang, M., A. Rabaey, 2002. 1V Heterogeneous Reconfigurable Processor IC for Baseband Wireless Applications. *IEEE International Solid-State Circuits Conference*.

Block diagram provided by Arnold Siegel, MTS of Wireless Systems Core Technology, Lucent Technologies.

Xilinx IPcenter:
(http://www.xilinx.com/ipcenter/processor_central/m)

icroblaze/performance.htm)

Xilinx Ipcenter: IEEE 802-Compatible Viterbi
Decoder V1.1
(http://www.xilinx.com/ipcenter/catalog/logiccore/docs/viterbi_802.pdf)

XtremeDSP™, Xilinx trademark.

Definition of XtremeDSP™
<http://www.xilinx.com/products/virtex4/capabilities/xtremedsp.htm>