

Automatic channel allocation using cognitive radio

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Abstract— Due to the high demand of free channels and lack of channel regulation policies unlike in the licensed spectrum, users do not sufficiently utilise the open band and cause interference. As a result, conventional and traditional radios proven not to be sufficient. The present paper proposes a channel allocation method based on cognitive radio to automatically assign a user to the best available channel in the 2.4GHz spectrum. The approach used here studies the BIUST radio spectrum to measure the different power levels which also communicates the traffic distribution. Based on this information, a channel with less power is the best channel to allocate a user without causing interference to other users. It is evident that the proposed method gives better connectivity as shown by the even distribution of power signals across all channels in the power-channel graphs. This is in comparison with the static approach where some channels are centralised while there are free channels. Without a need for the radio equipment to be configured, it is able to sense, measure and allocate itself using its software based environment unlike the conventional radio technology.

Keywords— cognitive radio, channels selection, unlicensed band, avoiding interference.

I. INTRODUCTION

In wireless radio network, the unlicensed spectrum was assumed to be free of interference and use of conventional radios was not a problem at first as there were very few devices using it until the introduction of the Internet of Things (IoT) [2]. This presented an opportunity for fast, cordless file transfer capabilities such as Device to Device (D2D) communications.

A computer scientist one day had an idea of implementing a cognitive program into the software defined radio (SDR) to enable it to automatically switch from one channel to another giving birth to the current Cognitive radio technology being used by engineers (cite). Cognitive Network (CN) became a very important concept as the saturation of spectrum became problematic, with this technology incorporated in to receivers, it enabled them to intelligently depict which channels are occupied and which are not. By instantly switching and avoiding occupied ones reduces channel interference.[2][3]

A. Motivation

Wi-Fi technology has become more than just a means to access internet, download, upload and browse. Sharing

technology (e.g. mobile hotspots) has made devices dependent on each other and continuously sharing data and all this is done with in the limited free license spectrum and Wi-Fi is mostly considered convenient way to link devices causing an increase in demand for this unlicensed spectrum. Whenever increasing is not an option, we resort to maximizing efficiency. In this instance, this work intend to find techniques to identify the best available channel with minimal interference. Cognitive radios have some level of intelligence unlike conventional radios which are made with the assumption that there is no interference in their operating spectrum, cognitive radios have already made it possible for devices to allocate themselves channels without clear distinction of the best available channel.

B. Research Objectives

1. To measure the amount of traffic/noise/interference in each band
2. To select the least utilized band with minimal interference
3. Radio should be able to re-assign itself the next best available channel if interference is detected

C. Scope of work

The radio physical layer involves greater performance frequency circuitry. We need to play around and control the hardware to achieve new techniques and flexibility. Once we have input the signals using a transducer module out of the analog domain via the USB dongle, we need to receive and also process communication signals. After that, it is crucial that we limit the bandwidth, be efficient in our utilization of radio frequency spectrum and here our focus is on the unlicensed one, address whatever differences between the transmitter and the receiver. Also handle radios which are in motion, adapt for the physical communications from the transmitter to the receiver, allocate radio software and hardware resources for efficient communications, adaptation by learning how and when to share information, re-route network traffic as links disconnect and reconnect, and know how to adapt to the current situation in this complex and congested radio communications environment. Wireless networks are challenging systems because of the complex and unstable nature of signal propagation. At the end of the research this

subject should be fully covered and addressed, and at the end of this paper the spectrum sensing and channel allocation problem will be addressed.

D. Report Structure

This report starts off with looking into the works of other engineers and researchers, their definitions and understanding of concepts, backgrounds and what they say about the variables/topics. By looking into the different works and connecting the ideas/variable helps in coming up with a possible solution to achieve the project objectives. Focus will be governed by IEEE802.11 regulations based upon: Cognitive Radio Technology, Wi-Fi access point and Software Development Radio environment.

II. COGNITIVE RADIO PROTOTYPE CONSTRUCT

A cognitive radio prototype system is built in MATLAB/Simulink and interfaced with two universal software radio peripherals to run in parallel. Besides a ready built Software Defined Radio ready-made software, MATLAB has a rich family of toolboxes that allows building software-defined and cognitive radio to explore various spectrum analyzing, prediction and management techniques [2]. All this will be built on the basis of. All waveform analysis such as sensing, cognition and management are done on the software host computer to be later employed on a microcontroller. The overall purposes such as high-speed operations of digital down and up interpolation and decimation inside the RDL-STR (Universal Software Radio Peripheral) [2][1]. At the end of this design chapter we should have a system design technology with aspects such as spectrum sensing, MIMO adaptabilities and spectral efficiency.

$$Y(t) = \begin{cases} n(t) \dots \dots \dots \dot{H}_0 \\ h \cdot y(t) + n(t) \dots \dots \dots H_1 \end{cases} \quad \text{Characteristic Equation}$$

Equation 1

From equation one, an analysis of a spectral density function $Y(t)$ can yield two outcomes. One being the null hypothesis H_0 and the other the alternative hypothesis H_1 . The null hypothesis refers to areas of the spectral density distribution which only have additive white Gaussian noise only (AWGN), $n(t)$ signifying that there are currently no active users. On the other hand the alternative hypothesis signifies that there is an active user $y(t)$ with a gain factor h currently active.[4]

Intelligent channel selection using history data

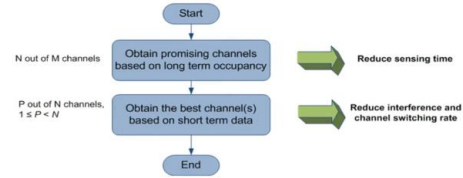


Fig 1: Algorithm flow

The method used to estimate the power spectral density is called the Periodogram which is calculated in units of power per radians per sample [2]. It also known as the Welch's method [4].

1. Cognitive Radio in MATLAB/Simulink implementation

In order to get an idea and better understanding of the concept of cognitive radio and its channel selection capabilities so we come up with techniques to better it. A basic MATLAB R2008a system with spectral efficiency algorithm is created to simulate the cognitive radio operations running the algorithm in figure 1 using the periodogram function.

2. Software-defined radio is a

communications structure where components that have been traditionally implemented in hardware (e.g. amplifiers, mixers, detectors, filters, modulators/demodulators, etc.) are instead implemented by means of software on a personal computer or finally on an embedded system. Using a device such as the one on figure 2, it acts as a transducer and an input into a computer's SDR platform where the signal manipulations will take place. [2]



Fig 2: RTL-SDR Radio

Possible Applications: CR channel selections have many ideal applications. This can be multimedia wireless networking such as in homes (e.g. casting, SHAREit app), emergency high data rate communications such as in the combat field (e.g. SSG tactical situation video), broadband

wireless networking in case of localized wireless network such as "hotspots".

III. RESULTS

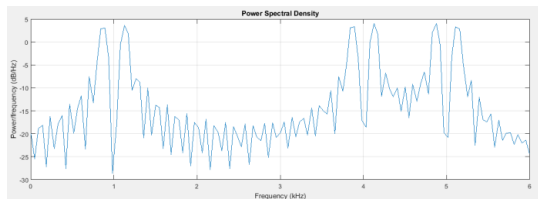


Fig 3: Initial PSD

For this research, five channels are being used for the tests rather than the actual 13 channels commonly available. From the results shown in figure 3, channels 1, 4 and 5 are currently occupied by networks which are referred to as primary users (PU's). These could be mobile hotspots, Wi-Fi networks, Bluetooth connections etc.

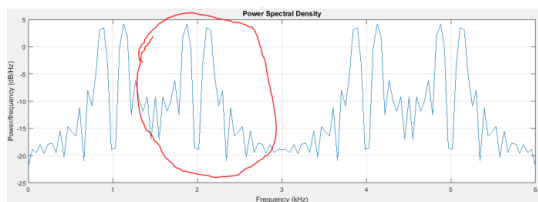


Fig 4: Final PSD

Initially we had 3 primary users operating in the unlicensed band. In order to an additional user, the forth user, which will be the secondary user (SU) with the cognitive radio program. It will run the cognitive radio algorithm embedded in it and eventually come to a decision on the best channel to assign to having considered all factors. In this instance, from just visual observation of figure 3 we can conclude that channels 2 and 3 were the best choice because of their minimal network traffic. Through the Welch method the SU was assigned to channel 2 which was the best alternative as well as channel 3.

What makes cognitive radio using the Welch method most impressive is the ability to initially scan the different channels

and assign a new user such as in figure 4. Channels with traffic cannot be confused with AWGN because of the huge difference between the two energy levels.

Conclusion

Traditional wireless technology devices have limited coexistence and spectrum sharing mechanisms as compared to cognitive radio which is an adaptive system. Cognitive radio would offer greater Wi-Fi network synchronicity mechanisms currently using the advanced cognition. And eventually after further developments, forecasting techniques for various wireless communication systems. Secondly, we developed a prototype environment (testbed) for manipulation, experimenting and emulating the cognitive radios on-top-of software defined radios built in MATLAB/- Simulink and interfaced with an RTL-SDR Radio dongle from Adafruit. The research challenges of cognitive radios are also briefly considered.

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