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RESEARCH ARTICLE

Evaluation of Spectrum Utilization through Cognitive Radio

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ABSTRACT

The analysis of spectrum usage and signal identification, using cognitive radio, was done to identify frequencies that are vacant and is in use in Delta State, Nigeria. A simulink model was designed to analyze a specific frequency spectrum in Delta State, checking if all the frequency stations that range from 87.5-108 MHz are presently being used in Delta State, Nigeria. From the results, it was noticed that by using Software Defined Radio/Simulink, we were able to identify vacant frequencies in the range of frequency under consideration and it was recorded that there are 14 used FM station in Delta State, having 86% underutilized FM Station. Also, the simulink was able to validate the NCC radio station in Delta State, Nigeria. Hence, the analysis can be recommended in larger coverage.

Keywords: *Spectrum Utilization; Simulink Model; Delta State; Cognitive Radio; Signal Identification*

Introduction

New communication technologies emerge daily in recent times, all of which rely on the radio frequency (RF) spectrum for their operation (Lubna *et al*., 2022). Nevertheless, the RF spectrum, which ranges from 3 kHz to 300 GHz, appears to be fully utilized as communication regulatory bodies like the Federal Communications Commission (FCC) and Nigerian Communications Commission (NCC) have allocated specific blocks of the RF spectrum for particular purposes and have granted licenses for these blocks to designated users or companies (Miftah and Mohammed 2015). These assigned bandwidths are fixed to the respective bodies. As a result, it appears that there is a problem of spectrum scarcity for the secondary users, as new applications and services arise from time to time.

The issue of spectrum scarcity arises from the necessity to allocate bandwidth to these emerging applications. Much of the spectrum has already been allocated to primary users, resulting in the assignment of bandwidths within the RF spectrum to these primary users. (Damian *et al*, 2015; Higginson-Rollins and Rogers, 2013; Iyer *et al*., 2011). The existing regulatory polices ensure that license holders have exclusive rights to utilize the spectrum as no other parties may access it, hence protecting the licensee from interference (Hassanieh, et al 2014). To solve the problem of spectrum scarcity in the secondary user, we have to identify the spectrum holes. Spectrum holes are those which are created when primary users are not using the allotted spectrum to them at that particular time. Hence our aim is to identify the spectrum holes or white spaces and allot them to the secondary users, if there are any left**,** with the help of cognitive radio we can eliminate spectrum scarcity problem. One of the most revolutionary applications of CR is addressing spectrum scarcity in wireless communications. The spectrum is scarce primarily because of the way it is licensed. CR provides the technical framework for spectrum sharing of the underutilised spectrum (Haykin, 2015). Harnessing the underutilised spectrum for use by other devices will be key to the future success of ever increasing devices.

Liu et al. (2011) research focused on the impact of errors during spectrum sensing on the efficacy of multiple access layers within both primary and secondary networks. The findings highlighted that employing distinct designs for spectrum sensing and channel access mechanisms could significantly influence the performance of both primary and secondary networks. So, in this study a joint design of spectrum sensing and channel access mechanisms is used. This technique achieves significant improvement in throughput of both PU (Primary User) and SU (Secondary User) networks. GNU radio application in the field of spectrum sensing came into the communication filed by Amor Nafkha (2014). Energy detection is used in spectrum sensing with GSM band by Maheshkumar S. Pandit (2014).

The RTL-SDR that originated from a consumer grade Digital Video Broadcasting, terrestrial (DVB-T) USB device that enables users to listing to radio and watch digital television on their computer. However, engineers and developers in the SDR community unlocked its potential as a programmable SDR. The two primary components of the RTL-SDR are the Rafael Micro R820T digital television tuner and the Realtek RTL2832U DVB-T Coded Orthogonal Frequency Division Multiplex (COFDM) demodulator and the internal architecture RTL-SDR (Stewart *et al*, 2015). Now we know spectrum scarcity is due to inefficient utilization hence cognitive radio should have following properties such as flexibility, reconfigurable, awareness, adaptability, intelligence. Cognitive radio has to be flexible while operating within radio environment, reconfigurable means it has to be reprogrammable. With each operation cognitive radio should be aware of the effect of environment and it should learn to adapt with the changes in the radio environment. Also, we expect the cognitive radio to perform better. The cognitive radios technology is a solution to the problem of spectrum underutilization and spectrum artificial scarcity because of its ability to use the spectrum for communication whether licensed or not licensed, so long it does not interfere with other licensed users. However, for cognitive radios to utilize the spectrum, it most has the ability to sense the spectrum to know when the spectrum is occupied or unoccupied so as to avoid interference with other licensed users, this study is aimed to analyze spectrum usage using cognitive radio in Delta State Nigeria.

Materials and Methods

A simulink was design to interface the FM station in Delta State, it is made up of different model elements working together to produce spectrum sensing and channel access mechanisms using cognitive radio in MATLAB/Simulink environment. The tools utilized in this study include MATLAB/Simulink, an HP laptop, an RTL-SDR receiver dongle, and an antenna. The RTL-SDR receiver was configured with specific parameters: the center frequencies were selected for various frequency bands within the range of 87.5 to 108 MHz, and the tuner gain was set to 35 dB, as depicted in Figures 1 and 2.

The simulink design that is shown in Figure 2 has spectrum sensing and channel access mechanisms embedded in GUI with two major displays; the Fast Fourier Transform (FFT) display that shows the Fast Fourier Transform of signals in the frequency domain and the water fall display which shows a graphical representation of the signals across a frequency range, generally colour-coded to indicate signal amplitude or strength displayed over time. The display exhibits the FFT waterfall display, depicted in Figures 3, 4, 5, 6, 7, and 8, along with the Spectrum analyzer FFT, illustrated in Figures 9, 10, 11, 10, 12, 13, and 14. The FM radio spectrum was monitor in Delta State to identify the vacate/used spectrum.

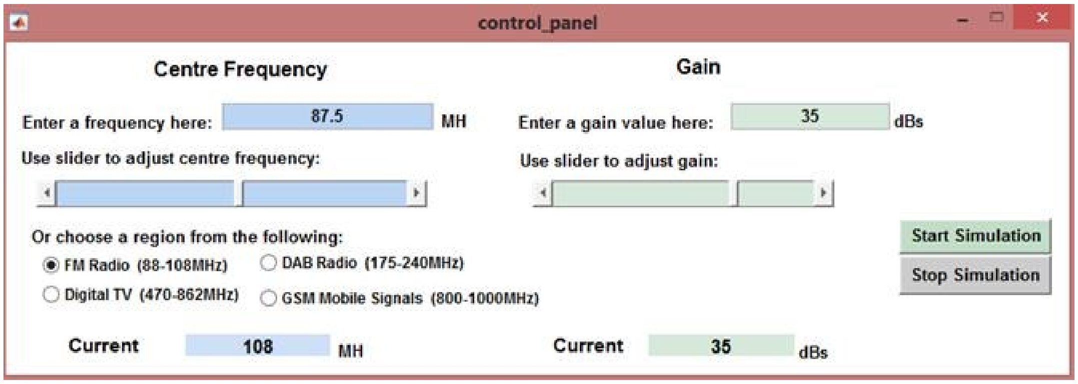

Figure 1: Frequency spectrum control plan

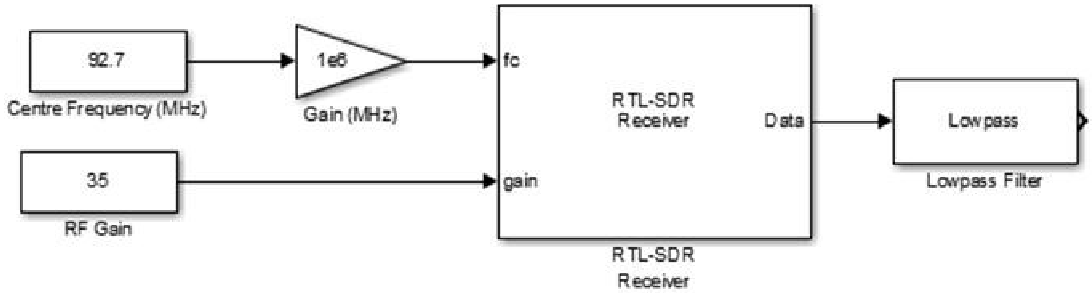

Figure 2: FM radio spectrum analyzer Simulink software diagram

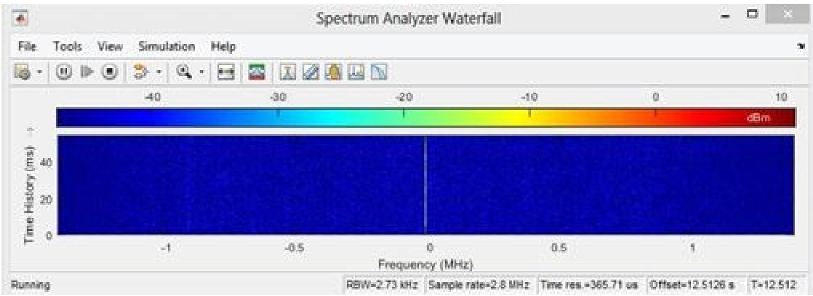

Figure 3: Spectrum analyzer Waterfall plot of FM radio.

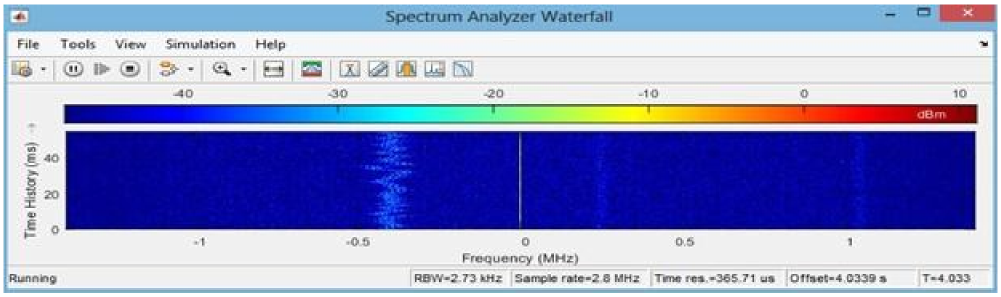

Figure 4: Spectrum analyzer Waterfall plot of FM radio.

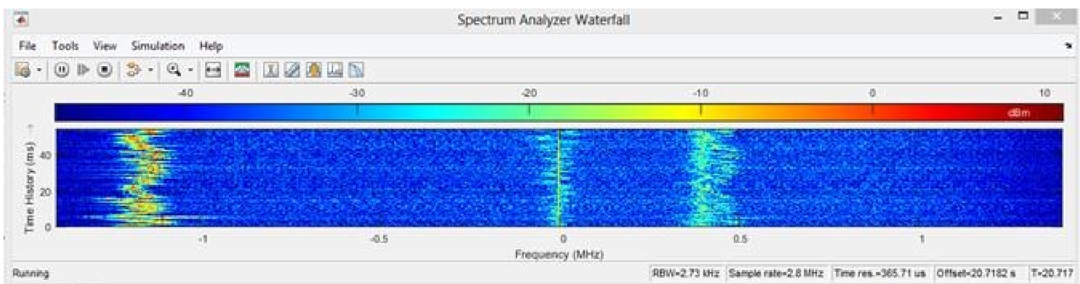

Figure 5: Spectrum analyzer Waterfall plot of FM radio

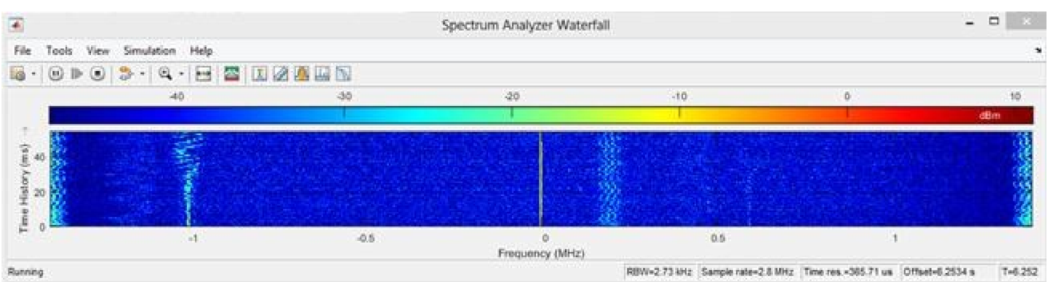

Figure 6: Spectrum analyzer Waterfall plot of FM radio

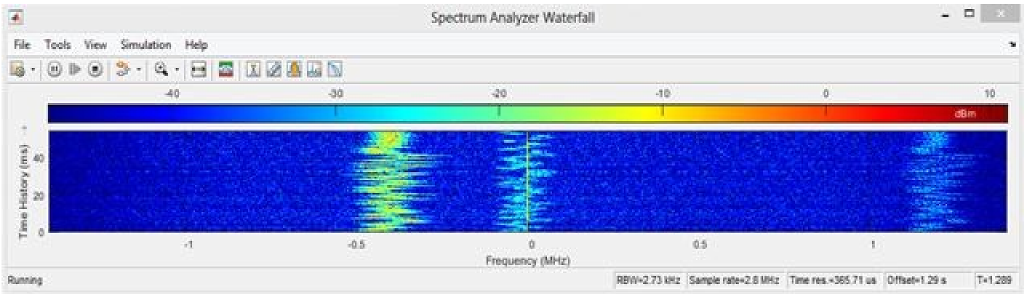

Figure 7: Spectrum analyzer Waterfall plot of FM radio

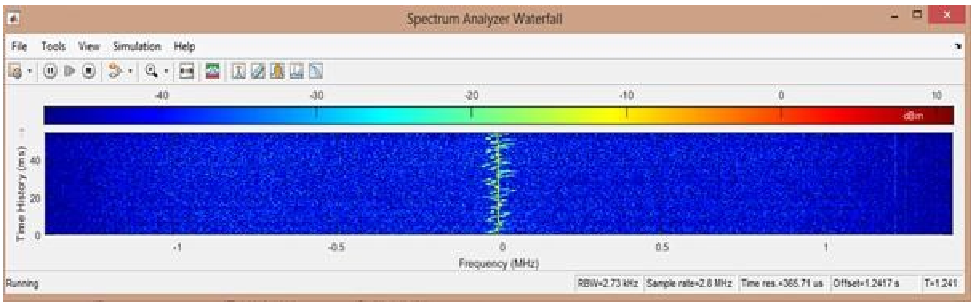

Figure 8: Spectrum analyzer Waterfall plot of FM radio

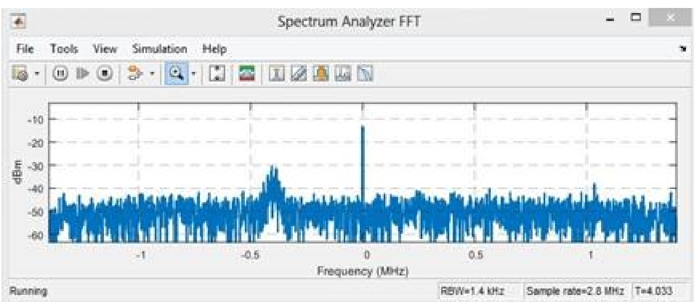

Figure 9: Spectrum analyzer FFT plot of FM radio

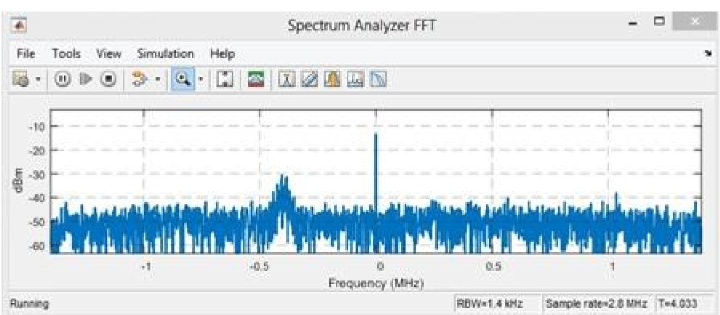

Figure 10: Spectrum analyzer FFT plot of FM radio

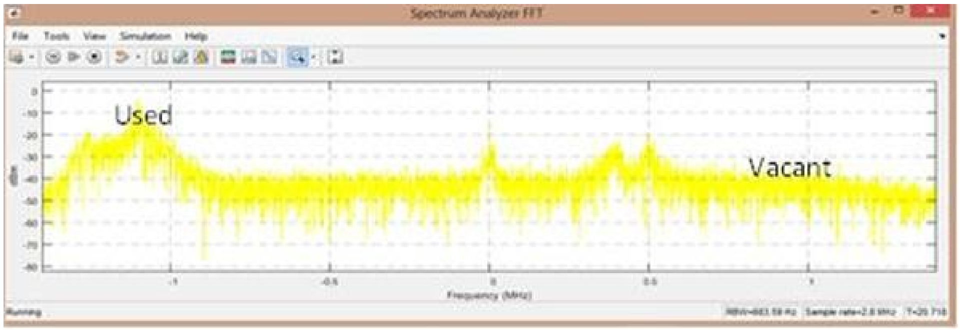

Figure 11: Spectrum analyzer FFT plot of FM radio

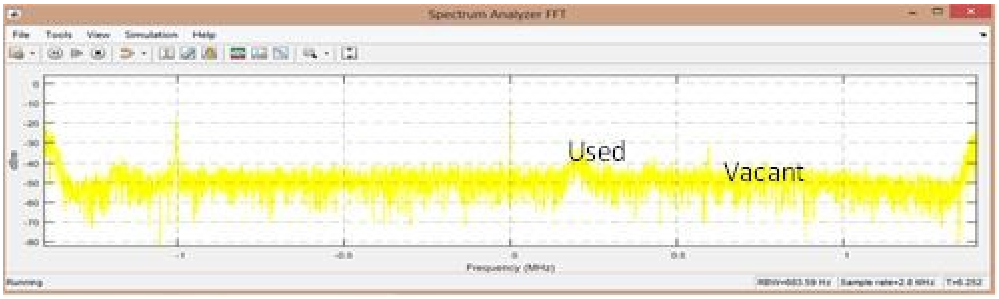

Figure 12: Spectrum analyzer FFT plot of FM radio

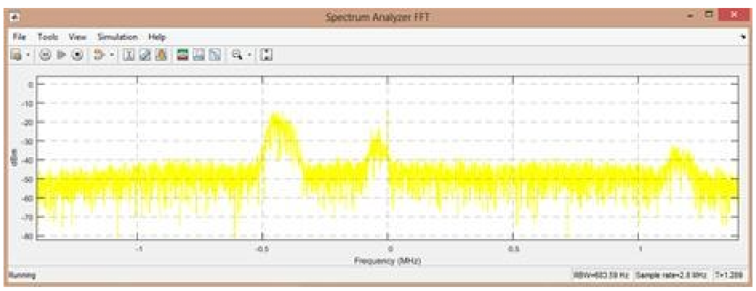

Figure 13: Spectrum analyzer FFT plot of FM radio

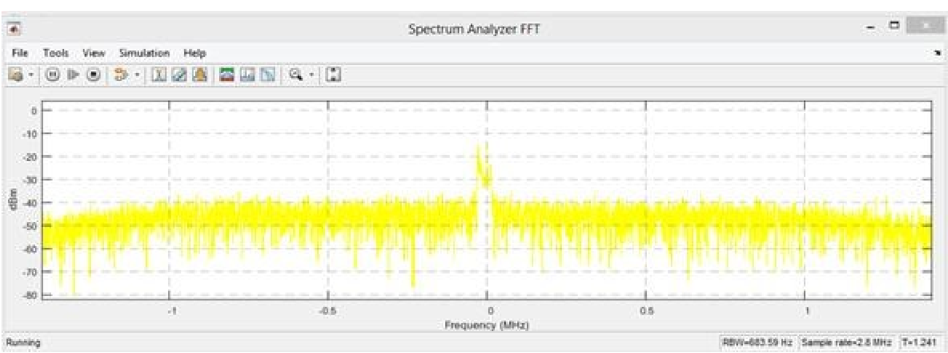

Figure 14: Spectrum analyzer FFT plot of FM radio

Predicted FM radio Stations in Nigeria

It was noted that from NCC recorded that Delta State has 14 FM station and the result validate the NCC record of 14 FM station in Delta State. Figure 15 displays the predicted FM radio stations in Nigeria, revealing that FM stations in certain states are underutilized.

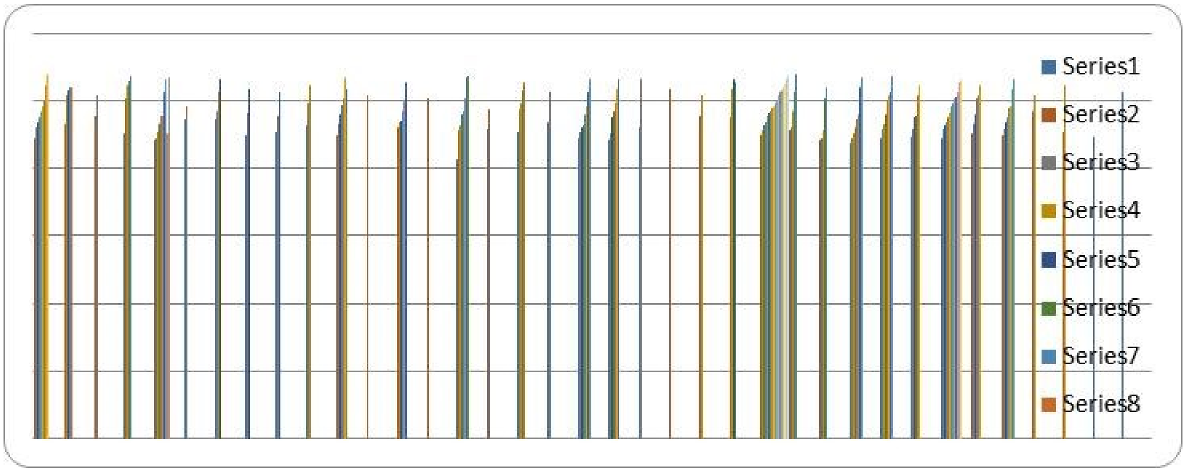

Figure 15: Chart showing the usage with frequency in Nigeria

Results

The study of FM frequency spectrum through cognitive radio (CR) technology, exploring and viewing the spectrum occupancy in real time using digital signal processing (DSP) software interfaced with the RTL-SDR model of cognitive radio discover unused frequency FM bands and used bands in Delta State. The develop Simulink Model detect the frequency and magnitude of a signal and compare it with a threshold value according to energy spectrum analyzing technique to determine whether or not the frequency is free, the sample was done in ten locations; it was recorded that there are 14 FM station in Delta State given 86% under utilised Station, some of the graph are shown in figure 4 to 14. From the figure it was observe that there are so many vacant/idle FM station in Delta State, Nigeria.

Conclusion

The study was conducted to monitor and analyze FM spectrum through RTL-SDR cognitive radio using a Simulink technique. The spectrum sensing RTL-SDR cognitive radio was implemented in real time and it performed spectrum sensing and signal prediction adequately with little short falls. Cognitive radio is one of the modern techniques in the field of wireless communication in order to solve the spectrum scarcity problem. Spectrum scarcity occurs due to the rapid increase of the applications in wireless communication which results in the problem of bandwidth. Hence in order to solve this problem cognitive radio follows the cognitive cycle in which spectrum sensing acts as a major procedure, spectrum sensing largely focus on the effective and efficient utilization of the spectrum. Here the analysis to find the white spaces are done by collecting the real time signal with RTL-SDR and experimented on Matlab, Simulink, GNU radio platforms. The study has shown that, FM station in Delta State have high vacant FM radio spectrum, and there is a need for spectrum management plan to address and control access to utilisation of the vacant spectrum in Delta State.

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