Evaluating Spectrum Utilization in Digital Transmission Networks

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ABSTRACT

The need for Digital Transmission has been on the increase over the years. Spectrums are basically a range of electromagnetic waves for digital transmission. Digital Transmission has poised great economic benefits to Networks Transmission Industries. However, with the wide spread demand for networks transmission, appropriate supervision of utilization and management is adequately required. A key component of the study is based on the input from the operational regions, industry stakeholders and Government Commissions. The study observed that, digital transmission has helped in managing the rate at which available spectrums are been utilized. Indeed, it takes 8MHz (Eight Mega Hertz) of Spectrum to carry a single Analogue Transmission, but with, Digital Transmission, it take the same 8MHz (Eight Mega Hertz) of Spectrum to carry as much as 20 (twenty) Digital Transmissions. This research work focused on Digital Transmission and provided solution to the need for a proper Analysis of Digital Spectrum Utilization. Applying the concept of a Fuzzy Set, and a robust analytic tool (MATLAB) was used as the analytic system model for a more scientific and feasible solution to sensitively analysis and spectrum utilization. The system was developed and evaluated using a scientific field data obtained from Nigerian Television Authority (NTA) Jos, for analysis purpose. Results obtained from the analysis shows that the use of Spectrum for Digital Transmission in Nigeria (Jos) has periodically increased, however not up to 50% (fifty per cent) were in use as at the end of December 2016. Recent concerns for conversion of Analogue Transmission to Digital is expected to bring about significant increase to Spectrum Utilization in Nigeria.

Keywords: Television Transmission, Frequency, Digital Transmission, Spectrum Utilization.

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1. INTRODUCTION

Technological advancement has brought about technical improvement in the society. Transmission has also moved (shifted) from the era of analogue to digital. In Nigeria today, the most popular means of getting a day to day information is via network transmission. The means are televisions and radio sets [2]. The receiving and transmitting of packets or signals are only possible if there is a presence of networks (wireless networks). Television and radio operate on receivers. These receivers are built to receive signals from transmitters, over a defined frequency, which is still only possible over a network. Transmissions travel through pathways known as spectrums which are radiations. In most cases, these radiations are emitted purposely by different devices (transmitters) for different purposes. Spectrums can be picked up by the use of a spectrum analyzer, and the Spectrum Analyzer helps in choosing the Spectrum (frequency) that is needed from a range of spectrums available in that environment, from a satellite. Spectrums are available because of the presence of satellites. Spectrums are measured in Mhz (Mega Hertz). Each level of a Spectrum represented on a Spectrum Analyzer represents the availability of a transmittable signals [3]. To get a particular signal (for example a channel from a variety of channels available on a network of channels or decoder), a broadband source has to be located. A broadband source in this context is a satellite (a satellite that is usually located in Space). Data usage are from a satellite, a satellite dish is required. The satellite dish is what is used for positioning, to help trap or get available signals from the satellite it is pointed towards [5].

Transmissions in this context can be referred to as the utilization of the available Spectrums. In the case of a television transmission, analogue channels are dedicated to a total of 8MHz of transmittable spectrums, for the transmission on one channel of broadcast, with one spectrum. This makes transmission simpler and more direct, because there is no usage of spectrums meant for one transmission (channel) by more than one transmission (channel) [4]. This means that for every distributable or transmittable channel, there is 8MHz each of spectrums available for every transmission.

Mathematically, it means that if there are 20 channels on 1 decoder, these 20 channels would have 8MHz of Spectrum each, that it receives from.

8MHz * 20 channels = 160MHz (1)

Represents the number of transmittable Spectrums for 20 Channels.

The above calculation indicates that there would be a total of 160MHz of Spectrums that the receiver will be receiving from. With the use of packet transfer of analogue transmissions, it is easier for these packets not to arrive at the required time stamp, and also very easy for the transmission to pick up interferences along the transmitted path.

The introduction of Digitalized Transmission brought up a fresh dimension in the era of transmissions, and also a perspective to the Utilization of Spectrums [1]. Transmissions were limited to packet transfers, until the advent of Digital Transmissions, which introduced the use of pulses. These pulses are in bits (0's and 1's), and they are much easier than the use of packets. Digital Transmission brought about the elimination of single utilization of the available 8MHz of spectrums by one channel alone, and introduced the usage of the same 8MHz by over 20 channels. With this technological advancement, the emergence of spreading of Spectrums, unused spectrums, are feasible.

1.1 Statement of Problem

Analogue methods of transmission are more susceptible to disturbances (noise) than digital channels. Audio and Video quality of transmission over a poor analogue broadcast is often easily noticed because of the snowy (blur) images and noisy (rushing water-like) sounds it produces. Analogue transmission makes use of the technology that transfers information as packets from a source (sender) to a receiver. An Analog signal varies continuously and its value is affected by all levels of interference (noise). Analogue transmissions required more bandwidth, due to the amount of Spectrum that is required for the transmission of only one channel. Transmitting an analogue channel doesn't share any part of its spectrum with other channels, which gives enough room for interference (noise) within the transmission.

1.2 Research Objectives

The main aim of this study is to model a system capable of carrying out analysis on spectrum utilization in Digital Transmission in Nigeria within a specific range of time.
The specific objectives are presented below:

1. To identify and achieve issues centered on the utilization of spectrums in analogue and digital transmission networks.
2. To adopt a model that will effectively show the level of utilization in spectrum of digital transmission networks.
3. Simulate the mathematical model using a robust programming language that will provide quality performance measurements of Spectrum Utilization of Digital Transmission Networks as may be required.

2. REVIEW OF RELATED LITERATURE

With hundreds of telecommunications and broadcasting licenses granted since 1992, Nigeria is arguably the leading country in Africa with respect to spectrum deregulation and licensing Fola Odufuwa (2010).. Market reform has resulted in the rapid roll out of telecoms networks across the vast national landscape with access to basic telecommunications services now virtually obtainable everywhere. With more companies offering services, there is evidence of increasing pressure and scarcity of frequency spectrum for communications in Nigeria. Chris E. Mamodu (2011), analyzed the limitations and problems of terrestrial analogue television broadcasting with respect to spectrums, and the benefits that emerges from new services in the digital domain. Different spectrum bands offer different physical characteristics. Higher frequencies do not carry signals as far and do not penetrate buildings as easily, and lower frequencies have capacity limitations and create more interference.

The UHF spectrum is particularly attractive because it is located between 200MHz and 1GHz offering an optimal balance between transmission capacity and distance coverage. The released spectrum is known as the digital dividend. The digital dividend is a unique opportunity to meet the fast growing demand for wireless communication services. However, its benefit can only be fully reaped if proper planning is made, ahead of time, for the use of the released spectrum (Digital Dividend).

Longe Omowunmi Mary (2011) considers a model for analyses of the growth of spectrum utilization by Nigerian Television Stations. Longe Omowunmi established in her paper that; Broadcasting started in Nigeria in 1933 through the Radio Diffusion System (RDS), which relayed radio programmes especially news from the British Broadcasting Corporation (BCC). From the RDS emerged Nigeria Broadcasting Service (NBS) in 1950. Jide Julius Popoola and Rex van (2014). In wireless communications, the availability of radio spectrum is an indispensable key input. This is because radio spectrum is a principal component of wireless communications that supports today's information society. In the last two decades, wireless devices and applications have grown at an immensely fast rate. Mobile phones and wireless devices have outgrown fixed phones and wired devices respectively and reached deeply into lower income groups. Likewise, there are emergences of new wireless communications systems offering personalized services to users on the move. This trend which without any doubt is likely to continue (Olafsson, S. et al). At national level, the radio spectrum is still partitioned into frequency bands, which are licensed to operators or licensed users for a long time. The license gives the holder the exclusive right to use the assigned frequency bands for providing radio services.

Bara'u Gafai Najashi, et al (2013) looked into the usage (occupancy) and management of spectrum in Nigeria. They resolved that the rapid evolution in wireless communication which has led to the development of several standards has also brought about a perceived spectrum scarcity. Studies have shown that contrary to popular belief concerning spectrum scarcity, most of the allocated spectrum is heavily underutilized. This has led to several spectrum occupancy measurements mostly in the US, Europe and recently Asia to ascertain the utilization level of the allocated spectrum. These measurements will help in determining which bands will be suitable for the deployment of cognitive radio technology. An indoor spectrum occupancy measurement was conducted within the region of 700MHz to 2.5GHz in Abuja, Nigeria is presented. The results obtained indicated that large portion of the allocated spectrum is underutilized which could be considered for the deployment of cognitive radio paradigm in the near future.

Mahmooda, M.Vinod & Sagar Nayakanti (2013) proposed Goertzel algorithm for the development of a spectrum analyzer. They stated that the challenges with FFT based spectrum analyzers makes implementation of spectrum analysis difficult. Spectrum of a signal reveals the elements of the signal, and also the performance of the circuit producing them. Spectrum analyzer is a frequency-selective, peak-responding voltmeter which displays the amplitude of a sine wave. Spectrum analyzers are able to measure a large variety of input signals and in this way they are an invaluable tool for the RF design development and test laboratories, as well as having many applications for specialist field service. Goertzel algorithm plays important role in the electronics industry for analyzing the frequency spectrum of radio frequency (RF) and audio signals and has some preferred properties such as high speed, low area and low power consumption.

Goertzel algorithm is a recursive filter that aims at specified frequency in the spectrum. Spectrum analysis from the input signal has been replaced by the active development of a wide range of very specialized techniques and most of the existing spectrum analyzers are highly specific to a certain input signal and some research is pursued to integrate these techniques. Nevertheless, this work adopted fuzzy logic based approach for the development of an analytic process to analyze rate of spectrum utilization in Nigeria and research findings provide suggestions for a more suitable means of managing the usage of spectrums.

3. SYSTEM DESIGN & METHODOLOGY

Digitalized transmission is a more suitable method of data transmission. It provides a safer and more economical means of communicating over a network. Digital signals typically use fewer Spectrums for transmission of a vast amount of data. The use of a combination electromagnetic microwave signal technology as well as Radio frequency makes it possible for over 20 channels to use the resources of one channel, and almost impossible for interferences and interceptions digital transmissions.

3.1 Model Formulation

The maximum type of Linear Programming Problem is formulated since the objective is to determine the Utilization of Spectrum. The equation is modifies to also indicate if the frequency in use lies either within VHF or UHF.

The model is given as:

$$\text{Maximum } Y = \sum_{j=1}^{15} p_j x_j \qquad (2)$$

$$\text{Maximum } Y = \sum_{j=1}^{15} a_{ij} x_j \leq b_i \qquad (3)$$

$$\text{Frequency } F = f x_j \geq 0, j = 1, 2, \ldots, 15$$

Where Y is the objective function.
x_j represents the number of stations.
p_j represents the subscribers on the channels.
f represents the frequency of transmission.

3.2 Methodology

In order to achieve the research objectives this research work explore the following methods to investigate and simulate the Utilization of Spectrum in Digital Transmission Networks using the following approaches:

i) Analysis of both Analogue and Digital Spectrums.
ii) Formulation and abstraction of a model for analyzing the Utilization Spectrums of Digital Transmission Networks.
iii) Carry out a quantitative and qualitative analysis of the realistic data.
iv) Adopt a suitable and a robust Simulation Programming Language (MATLAB) for coding and for analytic findings.

The Fuzzy Logic approach will be adopted for implementation and for result generation.

4. RESULTS AND DISCUSSION

We represent the simulation result graphically to enable us interpret them with precision. We ran the simulation with several parameters, including the wave form of analogue and digital wave forms, the percentage of analogue spectrum usage, before the shift to digitalized transmissions, the number of spectrum carried by a single analogue and digital spectrum, the quarterly growth rate of the use of digitalized frequencies, the number of subscribers of the broadcasted digital frequencies, the number of digital boxes, the number of televisions operating on analogue and digital frequencies.

The results will be verified, interpreted and discussed objectively.

GRAPHICAL REPRESENTATIONS

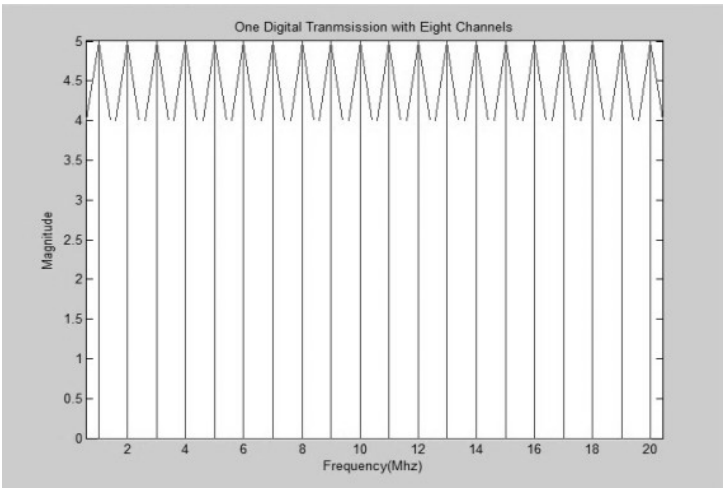

Fig 1: Graph showing twenty (20) channels on one Digital Frequency in Plateau State.

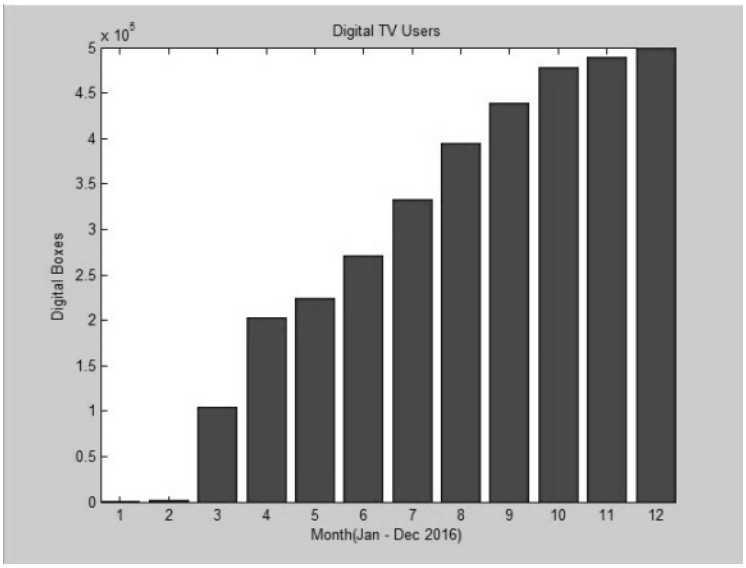

Fig 2:Digital Spectrum Usage in Plateau State.

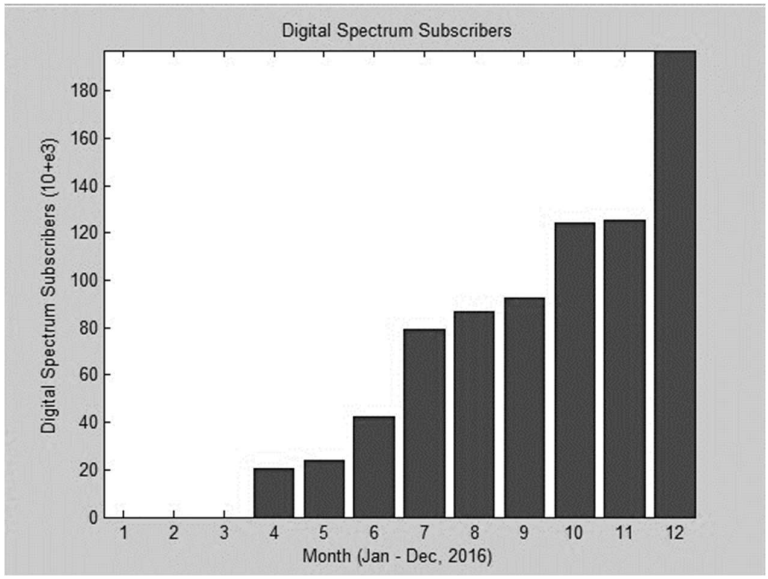

Fig 3: Digital Spectrum Users in Plateau State.

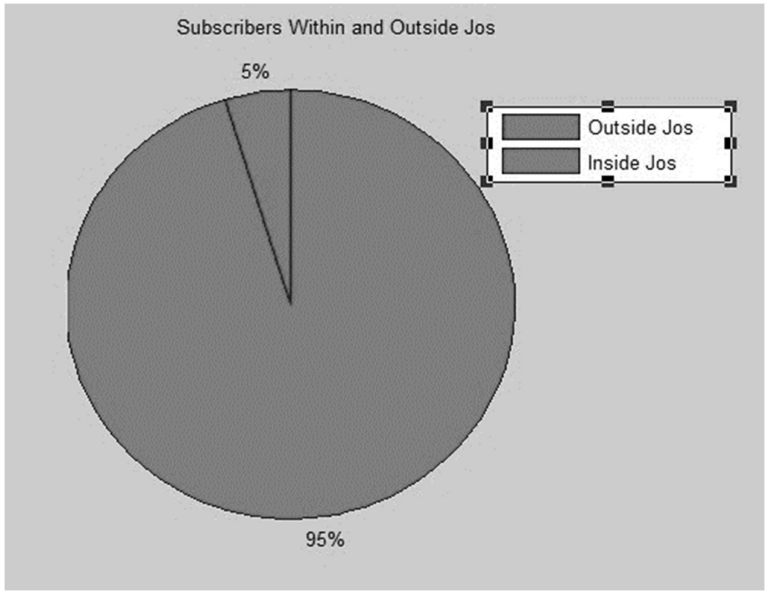

Fig 4: Subscribers Within and outside Jos, Plateau State.

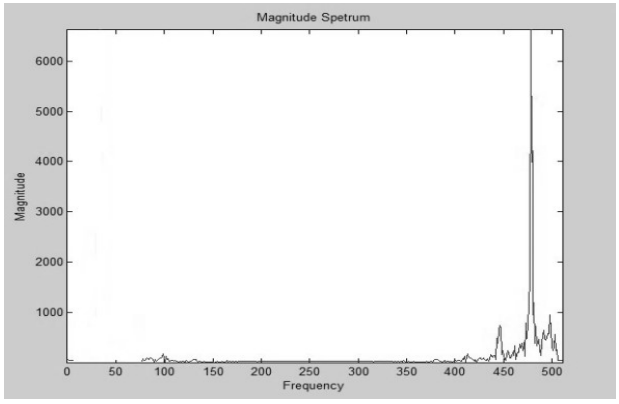

Fig 5: VHF and UHF Frequencies used by NTA (2016).

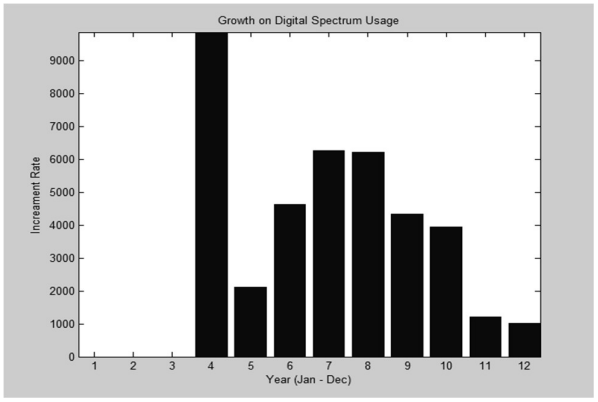

Fig 6: Number of added Digital Signal Subscribers per month outside Jos

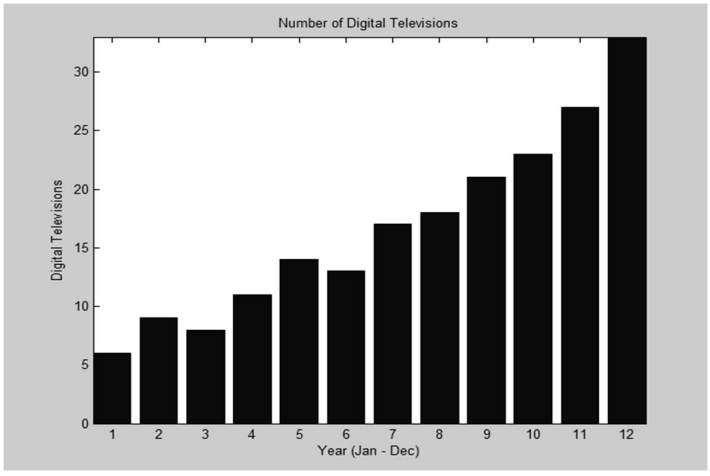

Fig 7: Number of Digital Televisions in Circulation in Plateau State.

5. SUMMARY, RESEARCH FINDINGS, RECOMMENDATIONS AND CONCLUSION

5.1 Summary

This project work is centered on Spectrum Utilization on Television Transmission. It gives an in-depth analysis on the utilization of frequencies, allocated to Nigeria (Nigerian Television Authority, Jos). The system was designed to help in knowing the level of spectrum Utilization of the Digital Transmission System Introduced in 2016 by NTA. It analysis the level of growth (purchase) of Digital Boxes (Set-Top Boxes and Digital Television Systems). It has also addressed issues mentioned in the statement of problem as well as the aim and objectives on this work. Hence, appropriate literature on past and current journals have been referenced in other to have and present a valid information. During the design of this system, an appropriate methodology for system analysis was adopted. MATLAB was greatly utilized in the implementation of this work.

5.2 Research Findings

An effective fuzzy logic system has been successfully deployed for spectrum utilization analysis. It is found that the proposed technique is feasible and provides a better solution than the conventional techniques.

5.3 Recommendations

This novel research work provides a highly optimized system. This shows that the proposed fuzzy logic based system outperformed the existing conventional scheme. The system is more robust in terms of performance. Hence, this system is highly recommended for Digital Transmission Network operator as well as network transmission and communication.

5.4 Conclusion and Suggestion For Future Research

A realistic system for the analysis of spectrum utilization of digital transmission networks has been developed. The systems considers reliability for factors that affects the utilization of spectrums of digital transmission networks. The fuzzy rules-based classifier was employed to optimize the systems performance, by determining the number of subscribers to digital frequencies over a given period. The amount of digital boxes (Set-Top Boxes and Digital televisions) using for the transmission is a valuable tool. To establish a threshold for the simulation, data were obtained from NTA (Nigerian Television Authority), 2016. The simulation of the existing system and optimized system showed that the proposed fuzzy logic based system outperformed the existing scheme and was more robust in terms of performance. An investigation of the systems effectiveness using a hybrid (fuzzy-neural computing) approach is a possible future direction to this research. The research can be extended to Spectrum Occupancy Measurements for Potent Cognitive Radio Utilization.

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