

## Development of Database Accessibility for Frequency Scheduling of TVWS Broadband Connectivity in Rural Areas Using Dynamic Spectrum Access Technique

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### ABSTRACT

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As a result of the switchover from analogue to digital transmission, Television White Space (TVWS) presented itself as good opportunity to supplement the existing licensed spectrum to ease the spectrum scarcity. Rural communities were usually not connected due to poor returns to the internet providers to provide broadband access to the areas. This research has prepared the framework and feasibility study for deploying broadband internet services using Television White Space (TVWS) technology in Ugbawka, a rural area in Enugu state, Nigeria. In this work, a Network Ping was run on five websites using three major internet service providers as backhaul to establish facts of poor or even non-existent internet services. Using Ping Plotter 5 Pro, accessing ieeec.com using MTN yielded a Round Trip (RT) average of 846.433 ms, with a loss of 83.8% packet over 10mins count. Radio Frequency (RF) Explorer and Carlson transceiver, Customer Premise Equipment (CPE) were used for field trials to determine availability of TVWS Frequencies. A database app was developed by writing some codes in the Basic for Android (B4A) Intermediate Development Environment (IDE). Empirical outdoor propagation model was developed with a 2.15 pathloss exponent while the indoor propagation model gave a pathloss exponent of 3.47 . An algorithm was developed, titled, TVWS Optimization Quadrature Amplitude Algorithm, (TOQA), where throughput of this project performed better by giving 60Mbps and 70 Mbps at Signal-Noise-Ratio (SNR) of 5dB while the conventional algorithm gave 30Mbps and 25 Mbps at same SNR value. The Bit Error Rate was lower than the conventional models used, giving the TOQA values of  $10^{-3}$  at SNR of 5 dB and  $10^{-6}$  at SNR of 30 dB while the conventional method gave  $10^{-1}$  and  $10^{-3}$  respectively at the same SNR values. With an Average of 56.2% network latency recorded in Ugbawka, TVWS will make a great impact on Internet connectivity if deployed.

Keywords : Television White Space, Radio Frequency, Customer Premise Equipment, Intermediate Development Environment, Optimization Quadrature Amplitude Algorithm, Signal-Noise-Ratio

## I. INTRODUCTION

The world at large has continued to witness huge demand for voice, data and video related services. This despite the current deployed infrastructural facilities in many countries including Nigeria. It gained widespread attention in the 1990s as a Dial-up Internet. Dial-up Internet requires basically, a phone line and modem device to access the internet at a data transfer rate of 56Kbps (Warner, 2018). This little connection speed made it time-consuming to download files and not feasible to stream music or video. In addition to its slow speeds, people were unable to make phone calls and browse the internet at the same time. As the total number of internet users around the world continued to grow, the public began to demand faster internet connections that could transmit more data. The response in the early 2000s was broadband technology that breathed new life into the internet. Broadband internet connection is high-speed access that allows a large volume of data to be transmitted at a data transfer speed greater than 256Kbps using an Asymmetric Digital Subscriber Line (ADSL).

### Real-Time Applications of TVWS

The limit of the real-time applications of TVWSs can only be our imagination. According to Khan et al., (2018), quite a number of deployment scenarios/applications have been conceived for communication systems based on TVWS. Many communication industries have already piloted projects and proof of concepts to show-case the effectiveness of TVWS-based communication. The Main driver for the deployment of TVWS is the characteristic radio wave in the UHF TV band, and its ability to penetrate deep inside buildings. Some of the promising applications are:

**Rural Broadband:** This is the major application of TVWSs that the researcher is very much interested in. Researches and conclusions from multiple literatures cited above clarifies that the rural areas could benefit,

to a great extent, from the deployment of TVWS owing to the sheer nature of the TV band waves having propagation characteristics to reach tens of kilometers.

It can therefore, be stated that in some rural areas, minimum levels of signals can be detected which could access sparingly, voice calls in some locations and a total blackout in the other. In the area of Internet connectivity; Network Latency was observed to be a big challenge. Network latency refers to the time taken for a packet data to travel from a sender to a receiver *verse versa*. Latency may also involve transmission delays, exhibiting properties of the physical medium, and processing delays such as passing through proxy servers or making network hops on the internet. Generally, the performance and network speed of a network are usually expressed as bandwidth. Hence the average person is more familiar with the term, bandwidth, because manufacturers use that as a metric for advertisement and latency matters to the end users. Distinguishing the complications between Latency, Throughput and Bandwidth; by drawing an analogy with a pipe; the **Bandwidth** determines how narrow or wide the pipe is; the narrower it is, the less data it is able to push through and *verse-versa*. While Latency refers to time taken to transfer data, **Throughput** refers to the total number of data that can be transferred over time.

Low network latency can be caused by a lot of factors, some of which includes transmission medium like Wide Area Network (WAN) or fiber optic cables. All these have limitations and can affect latency due to their nature. WAN latency occurs when the network is busy dealing with traffic to the extent of delaying other requests as the hardware can't handle them all at maximum speeds. An error or other problem with the hardware can increase the time it takes for the hardware to read the data, which is another reason for latency.

## II. METHODS AND MATERIAL

### Creation of Database for TV White Spaces

The Database creation was carried out in two stages. The first was to collate Data while the second step was the Computer Programming, using data in Excel Spreadsheets and Android software programming tools.

#### (a) Data collation.

This first step taken was the measurements conducted through drive test. The measurements taken involved the recording of the Transmitters Received Signal Strength (RSS) and other transmitter parameters, like the transmitted and received power. Using the set up in figure 1, the RF Explorer repeatedly scanned the spectrum from 240 to 960 MHz for 24 hours. However, RF explorer is designed to be configured manually, with a maximum scanning range of 100 MHz. Using RF Explorer Spectrum Analyzer showed that on any channel occupied by a Primary User, the threshold level in absence of any transmission is -107dbm. Figures 2 and 3 respectively show signal strength display of the routs and Rf Explorer Live Data Debug This was confirmed through repeated measurements on Enugu State Broadcasting Service (ESBS) frequency that transmit on 703.25 MHz. Keeping sufficient cushion for low power transmissions, we chose -107 dBm as the noise threshold for the measurements.

#### (b) Creation of Database for TVWS using Android software.

Using an Android software, B4A with its development kits; Android Software Development Kit (SDK) and Java Development Kit (JDK) was installed on a PC with windows 10 (64 bit) operating system (OS). The Database app was developed by writing some codes in the B4A IDE and designing layouts in the visual designer. Regular testing of the final product of written codes and designed layouts were carried out

using a mobile phone (Samsung J-200) and an emulator (BlueStacks App Player) to view the user-interface of the developed app.

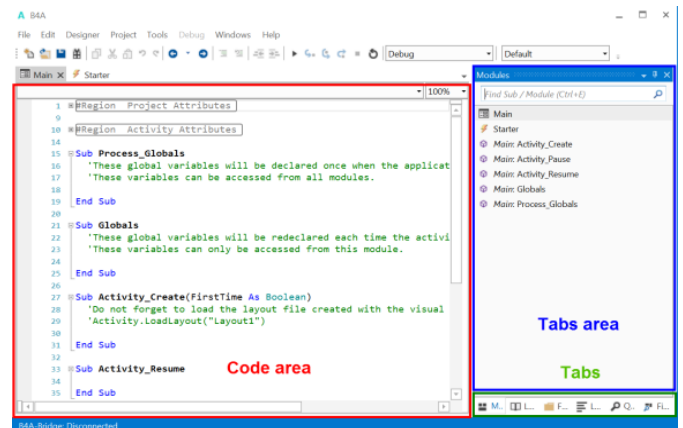


Figure 1 : Integrated Development Environment (IDE)

#### (a) Implementation phase

The database application was implemented on a PC with windows 10 (64 bit) operating system (OS) and a rapid application development (RAD) tool known as Basics for Android (B4A) with its development kits; Android Software Development Kit (SDK) and Java Development Kit (JDK) were used as the standard android development environments.

#### (b) Visual designer

The Visual Designer allows generating layouts with either the Abstract Designer or with a real device or an emulator.

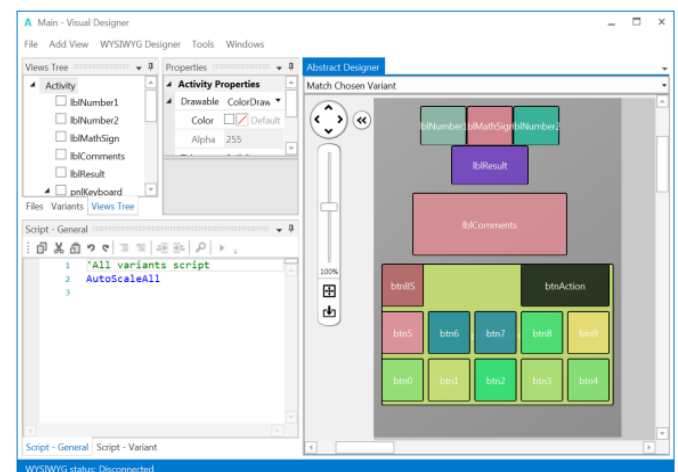


Figure 2 : B4A Visual Designer

The final product of the developed database app was named 'UJ – TVWS Database' an acronym for Ujams

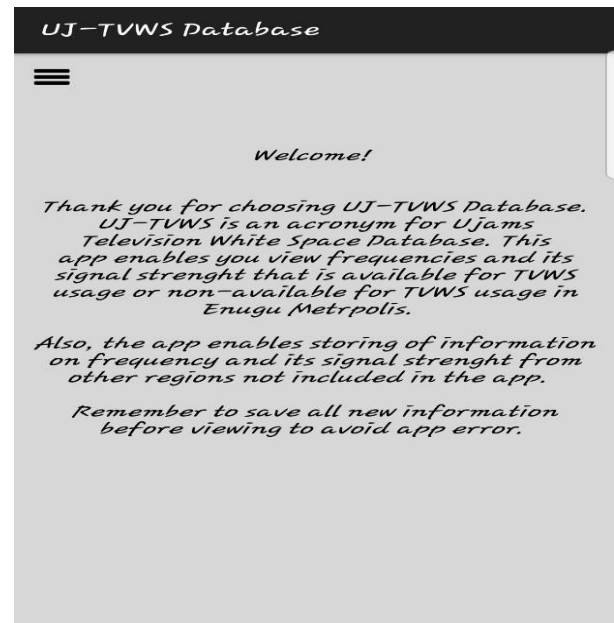
Television White Space Database. The operating environment of the database app is Android and supports mobile phones and Tablets that uses Android operating system of version 4.4 or higher. UJ – TVWS Database was implemented with 6 main user interface screens and 10 Tables.

a. The 6 main user-interface screen consist of;

- i. Logo screen: this shows the logo used to design the database app,
- ii. Home screen: This contains a write-up for the user to understand how to operated UJ-TVWS
- iii. Menu screen: this screen help the user on how to move around the app.
- iv. New database screen: the screen enable the user save new frequencies and signal strength for other regions in a database not included in the app.
- v. Enugu metropolis screen: this screen enable the user view all the frequencies and signal strength obtained from nine locations (Ugbawka, Akpasha, Esuth(Enugu), Esuth(Agbani), Ngwo, Udi, Four Corner, Ogui and Okpara Square) in Enugu states.
- vi. Other region screen: this screen enable the user view frequency and signal strength of other regions the user stored in the app

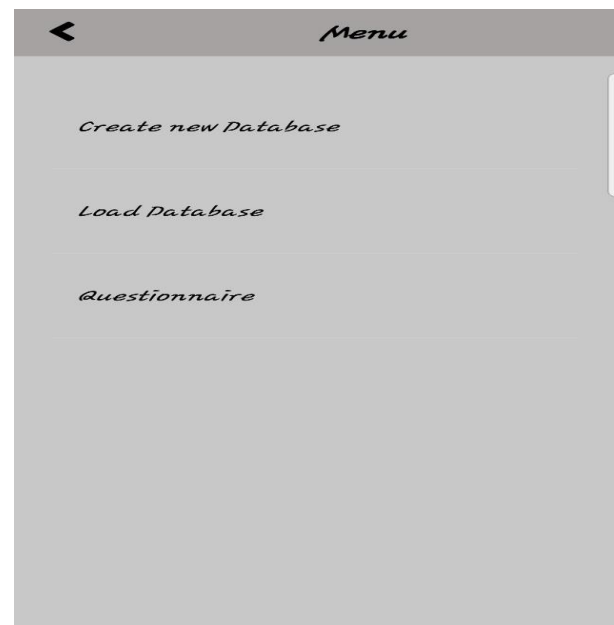


(a)

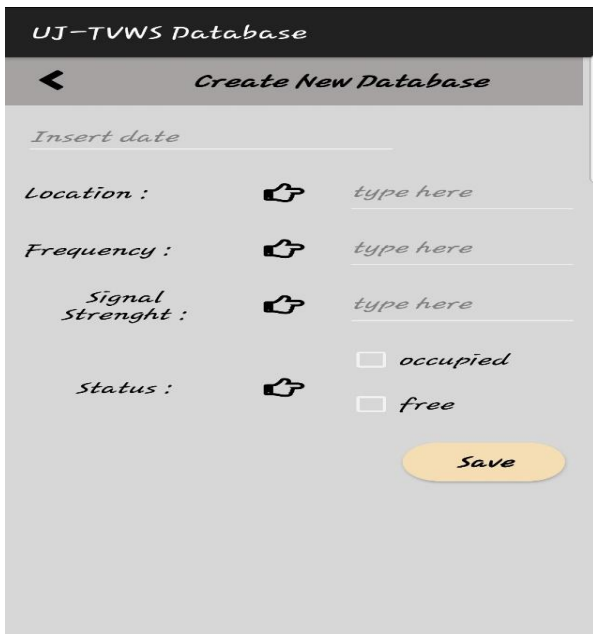


(b)

Figure 3 : Logo Screen



(a)



(b)

Figure 4 : Menu Screen

Frequency (MHz)	Signal (dBm)	Status
470.18	-94.5	occupied
470.631	-94.5	occupied
471.081	-95	free
471.532	-95	free
471.982	-95	free
472.432	-95	free
472.883	-94.5	occupied
473.333	-94.5	occupied
473.784	-95	free
474.234	-94	occupied
474.685	-95	free
475.135	-95	free
475.586	-94	occupied

(b)

Figure 5: Enugu Metropolis screen



(a)

**The 10 Tables consist of;**

- i. New data Table: it contains frequencies and signal strength of other regions stored by the user.
- ii. Ugbawka Table: it contains frequency of 470 – 740 MHz and signal strength of above -61 dBm obtained from Ugbawka location in Enugu state.
- iii. Akpasha Table: it contains frequency of 400 – 800 MHz and signal strength of above -66 dBm obtained from Akpasha location in Enugu state.
- iv. Esuth2 Table: it contains frequency of 400 – 800 MHz and signal strength of above -36 dBm obtained from Enugu State University Teaching Hospital (Enugu town) location in Enugu state.
- v. Esuth3 Table: it contains frequency of 400 – 800 MHz and signal strength of above -32 dBm obtained from Enugu State University Teaching Hospital (Agbani town) location in Enugu state.
- vi. Fourcorner Table: it contains frequency of 400 – 800 MHz and signal strength of above -75 dBm obtained from Four Corner location in Enugu state.
- vii. Ngwo Table: it contains frequency of 400 – 800 MHz and signal strength of above -59 dBm obtained from Ngwo location in Enugu state.

- viii. Ogui Table: it contains frequency of 400 – 800 MHZ and signal strength of above -64 dBm obtained from Ogui location in Enugu state. For the developed app, there was a Post-Study System Usability Questionnaire includes
- ix. Okparasq Table: it contains frequency of 400 – 800 MHZ and signal strength of above -42 dBm obtained from Okpara Square location in Enugu state.
  - i) thank you for choosing Su-press Monitor.
  - ii) The purpose of this assessment is for the researcher to know about your interaction with Su-press Monitor for app improvement.
- x. Udi Table: it contains frequency of 400 – 800 MHZ and signal strength of above -63 dBm obtained from Udi location in Enugu state.

**Table 1 :** The coordinates of locations where measurements were carried out

Location	Longitude	Latitude
Okpara Square	7.519779°E	6.439927°N
Ozalla/Udi Road by Four corners	7.464213°E	6.322740°N
Four corners by Old road	7.486038°E	6.314934°N
ESUT Agbani	7.524847°E	6.310197°N
ESUT Enugu Faculty of Enginrn	7.511045°E	6.431746°N
Ogui Road by Zik’s Stadium	7.496372°E	6.442805°N
Ngwo/Okpokoro/Nineth Mile	7.4071824°E	6.435976°N
Udi/Amokwe Town	7.396007°E	6.322866°N
Ugbawka Renaissance University	7.35543°E	6.33394°N

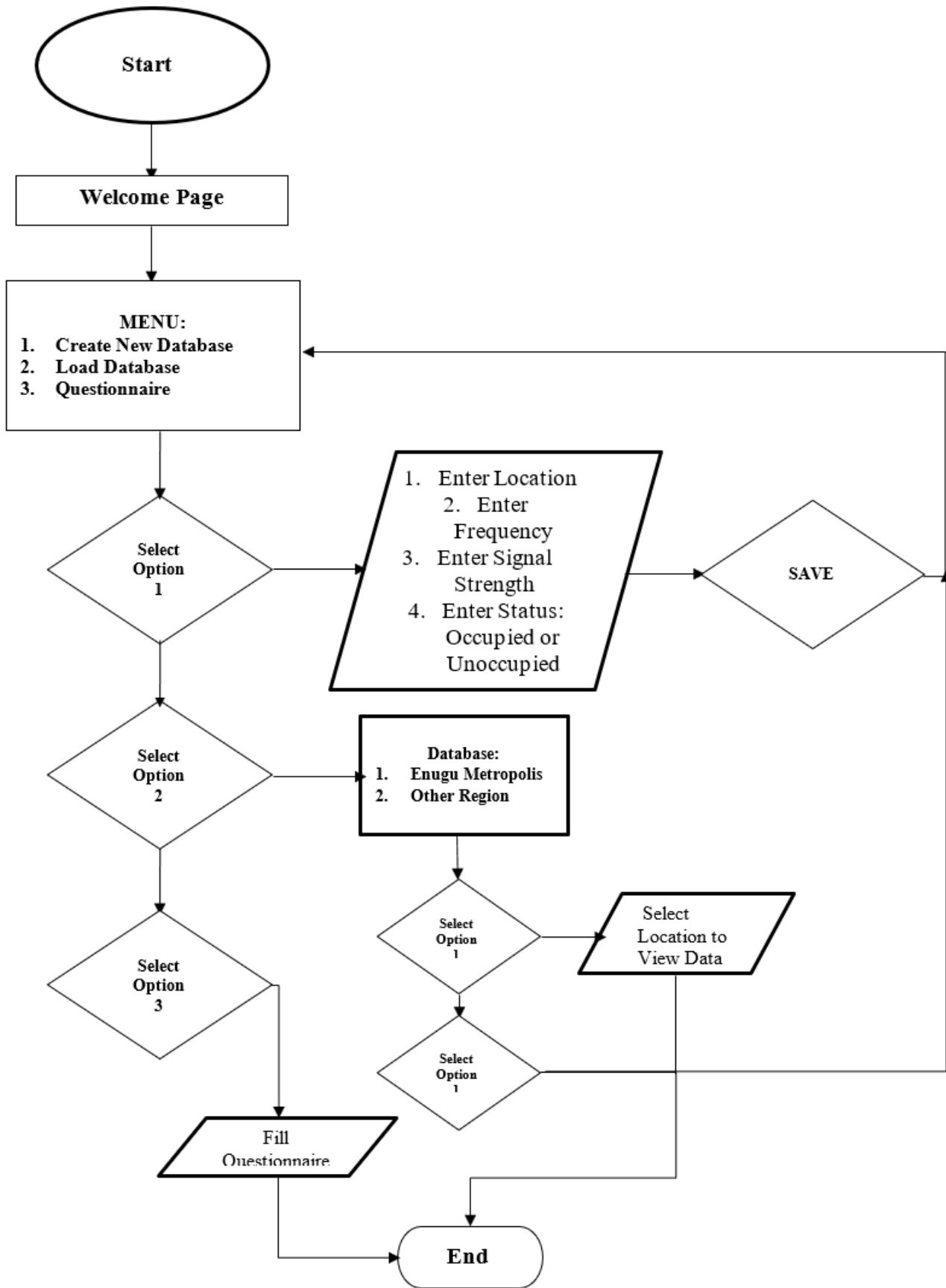


Figure 6 : The flowchart for the database creation procedure



### III. CONCLUSION

In this paper, the various details on the major different between the wireless broadband technology for Television white spaces and traditional wireless technology systems were currently used. It was observed from the analysis that a well designed database has the ability of accepting more new database entries from observation which could be used by a geolocation database procedures to provide opportunistic access to broadband internet connections.

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