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Modelling Television White Space Frequencies for Broadband Internate Connectivity in The Rural Area of Nigeria Using Dynamic Spectrum Access Technique

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ABSTRACT

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 ieee.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. 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. A 34.0% improvement was achieved when the dynamic access technique offered by this project was implemented on the TVWS network.

Keywords : Network, Modelling And Frequencies

I. INTRODUCTION

1.1 Background

People living in the rural areas of the world, including Nigeria, are deprived of either complete internet or partial connection to the internet. There is urgent need to connecting the rural areas so that communication is made easier for improved agriculture, adequate health care and prompt disaster management. Reliable spectrum resources management can go a long way to solving the problem. Managing spectrum resources typically involves guaranteeing minimal interference levels between spectrum licensees, including radio stations, broadcast television stations and telecommunications providers. This task can be difficult. Available spectrum has however been licensed for Television (TV), Satellite and Cellular, and according to a spectrum measurement report by the Federal Communications Commission (FCC), most of these licensed spectrum are significantly underutilized. Countries established regulatory bodies in order to reduce interferences between the primary users (PU) and secondary users (SU). Nigeria has the Nigerian Communications Commission as an Independent National Regulatory Authority for the telecommunications industry. The International Telecommunication Union, (ITU), is the United Nation's body which controls the spectrum usage round the world. The Federal Communications Commission, FCC, is the United States' primary authority for communications law, regulation and technological innovation globally. The Office for Communication (OFCOM),is the United Kingdom's, Telecommunications regulatory body. The world is divided into three regions for the purpose of frequency allocation and Nigeria falls within Region 1. Radio frequency spectrum is one of Nigeria's key natural resources of great economic value as a result of its direct application in telecommunications, broadcasting, military operations, and scientific research in addition to a range of other socioeconomic activities such as social services, law enforcement, education, healthcare and transportation. Nigeria's frequency spectrum allocations follow ITU standard.

A new technology that is offering some relief to the spectrum scarcity is the Dynamic Spectrum Access (DSA) which makes use of cognitive radios. Cognitive radio is an intelligent radio frequency transmitter/receiver designed to detect the available channels and adjust its transmission parameters enabling more communications and improving radio operating behavior. A cognitive radio system can observe and learn from its environment, adapt to the environmental conditions, and make decisions in order to efficiently use the radio spectrum. It allows Secondary Users, (SUs) to use the Primary User's (PU) assigned radio spectrum when it is temporally not being utilized. As Roberts S. et al (2015) put it, the first globally harmonized opportunity to use DSA technology is in the unused TV band frequencies known as the TV White Spaces (TVWS). TV White Space enables variety of use cases ranging from low-power in-building media distribution to Machine-machine applications. They are very suitable for delivering low-cost broadband access to rural and other unserved communities. Radio signals in the TV bands, in particular, the 470 MHz to 698 MHz range of UHF frequencies, travel over longer distances and penetrate more obstacles.

The Dynamic Spectrum Access (DSA) is proposed as a potential technology to exploit the inefficiently utilized licensed bands without harmful interference to the incumbent users, thereby solving the problem of spectrum scarcity. A recent application of DSA is in the TV Spectrum. On November 4, 2008, the FCC passed a historic ruling to allow unlicensed use of TVWS. On September 23, 2010, the FCC released the final rule for unlicensed operation in the TV broadcast bands.

TV White Space refers to TV channels that are not used by any licensed services at a particular location and at a particular time. TVWS is a new wireless communication technology that provides broadband speed data links over several kilometres in license-free spectrum. Devices contact qualified geo-location database that provides channels and power transmission parameters at a set minutes intervals.

Preliminary survey made in Enugu on TV white Space showed that it is still at its early stages in Nigeria. For regulatory reasons, white Space Devices (WSDs) operate in the UHF TV band in the range 470 MHz to 790 MHz (channels 21 to 60). It shares spectrum with Digital Terrestrial Television (DTT) and Public Making Special Event (PMSE) and will be license-exempt, (FCC 2008). Again, there should be a low probability of harmful interference to the primary users and even to the networks above 791MHz to 860MHz range. Also the network that uses the emergency services, PMSE, short range devices, business radio and maritime radio below the band 450MHz to 470MHz should be protected against interference.

The term "TVWS" or simply white space, is used by the FCC to represent the locally unoccupied TV channels located in the Very High Frequency (VHF) and Ultra High Frequency (UHF) bands, (Mekeka C.et al, 2014). The radio signals in TV spectrum travel farther and penetrate obstacles more effectively than that in typical cellular and Wi-Fi Industrial, Scientific and Medical, (ISM), owing to the lower frequency of TV bands (Palka P. and Neumann P. 2014). So, to utilize TVWS is of great potential for satisfying the increasing demand for wireless spectrum and providing better services and capacity.

II. METHODOLOGY

2.1 Evaluation of the Internet access at the Test Bed

In line with the first objective of this work, the evaluation of internet access at the testbed was done to establish the availability or non-availability of internet connection. The reason for this is to demonstrate the need for TVWS. Different available network carriers were sampled on the testbed. The network parameter considered is Latency. This was done, first, by using the Ping Plotter 5 Pro Service on five websites; the researchgate.com, the ieee.com, the iet.com, the googles.com and facebook.com. The ping service only was hosted through the Microsoft Windows Command line (CMD) prompt and it did not return favorable values for websites like researchgate.com, as the domain does not accept ping services. It was now deployed with obtained results of packet roundtrip from the server to the receiver and back. For the five websites that were utilized - iet.com, ieee.com, researchgate.net, google.com, facebook.com; the measurements lasted between 5-20 mins each. The limitation to cover longer hours of roundtrip measurements was as a result of power shortage. The researcher's testbed had no public power supply each of the time of measurement. The Table 2.1 and Figure 2.4 below show the different return trip rates on Airtel network. The rest of the results for the GLO and MTN are shown in chapter four.

Table 2.1 : AIRTEL Network Ping Test result obtained at the testbed.

t(mins)	ieee.com		iet.com		researchgate.com		google.com		facebook.com	
	RT(ms)	PL(%)	RT(ms)	PL(%)	RT(ms)	PL(%)	RT(ms)	PL(%)	RT(ms)	PL(%)
1	580.2	25	960.1	17.4	836.2	8.3	74	-	128.6	12.5
2	748.5	8.7	695.4	16.7	796.1	41.7	96.4	-	81.5	-
3	702.3	4.2	816.5	12.5	264.7	-	104.1	-	83.3	-
4	545.2	54.2	806.3	-	321.1	-	144.7	-	112	-
5	756.3	33.3	674.2	33.3	441.3	4.2	176	8.3	103.4	-
6	786.8	12.5	896.9	8.3	256.1	-	157.7	8.3	225.8	33.3

7	292.2	-	851.1	16.7	297.8	-	124.7	20.8	175.3	13
8	264.5	-	298.9	-	280.7	-	111.2	16.7	152.6	16.7
9	400.1	-	354.2	-	294.7	-	134.6	-	147.6	16.7
10	294.9	-	443	4.2	499.6	4.2	120.9	-	127.1	-
AVG	537.1	22.9833	679.66	15.5857	428.83	14.6	124.43	13.525	133.72	18.44

Performances of different Internet Service Providers (ISPs) through measurements to show the latency of the network in the region, using three different ISP Networks – MTN, Glo, and Airtel as samples was poor. The switch to an alternative Network test software, PingPlotter Pro 5, reluctantly produced some results as can be seen in Figure 2.1.

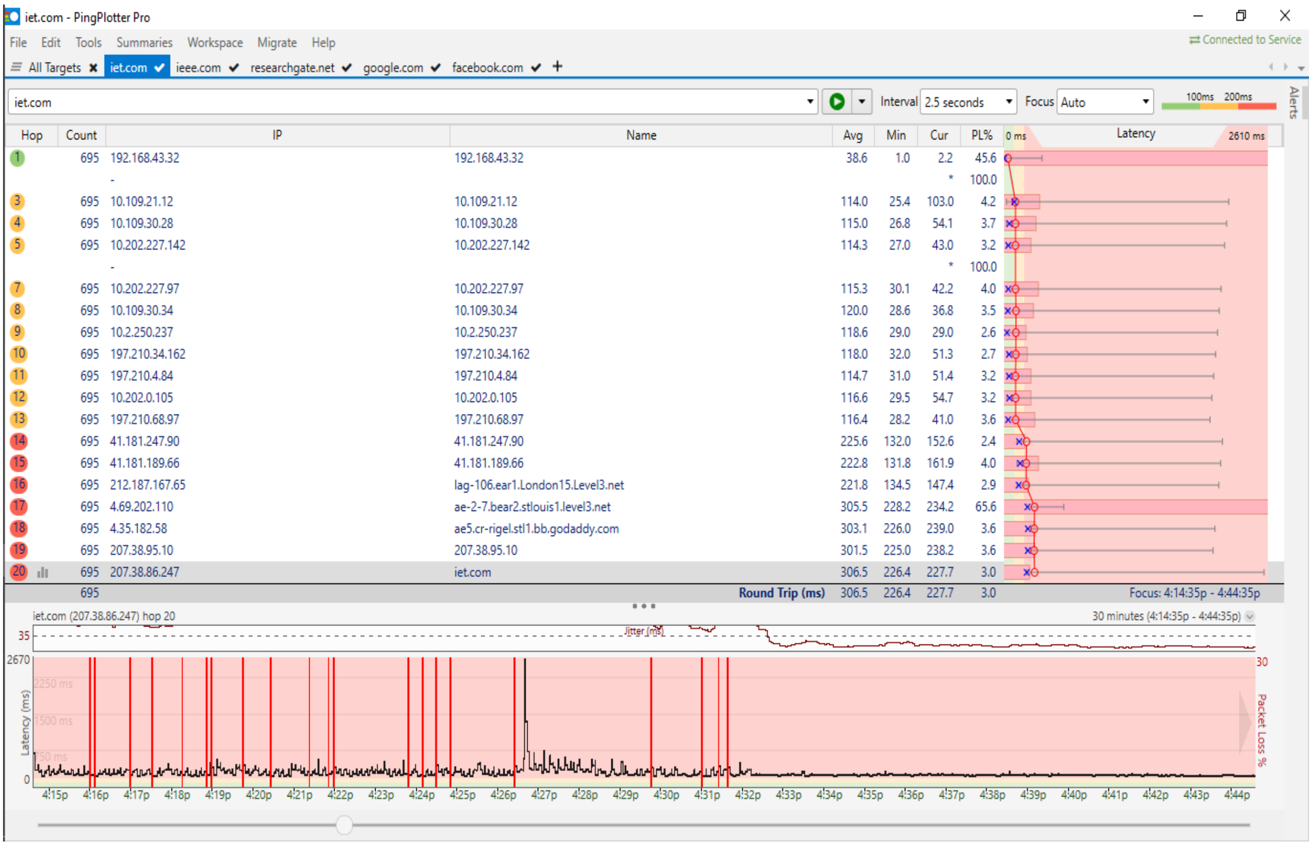


Figure 2.1 : Sample Readings obtained using Pingplotter Pro 5 network test app (Obtained from the researcher's computer Screen, using Sniping tools)

Figure 2.1 shows sample readings from the Pingplotter Pro 5, which shows the latency across the roundtrip for iet.com.

The second approach towards establishing poor internet connectivity at this rural area involved the measurement of Propagation of the MTN signals at its Network tower of ID T4662 located at Afor Ugbawka market square. Internet Connectivity emanates from a functional network tower and transmits to receivers within a geographical setting. At Ugbawka Axis, the closest available network tower, an MTN network tower, with ID T4662, located at Lat 6°15.3892, Long. 7°36.0085 served this purpose. The network tower is exactly 12km away from the researcher's test bed. The area is characterized with Tall trees, few houses and a nearby market. The Figure 3.5 shows the position of the tower and the three directions, monitored and their signal behavior measured, into the villages.

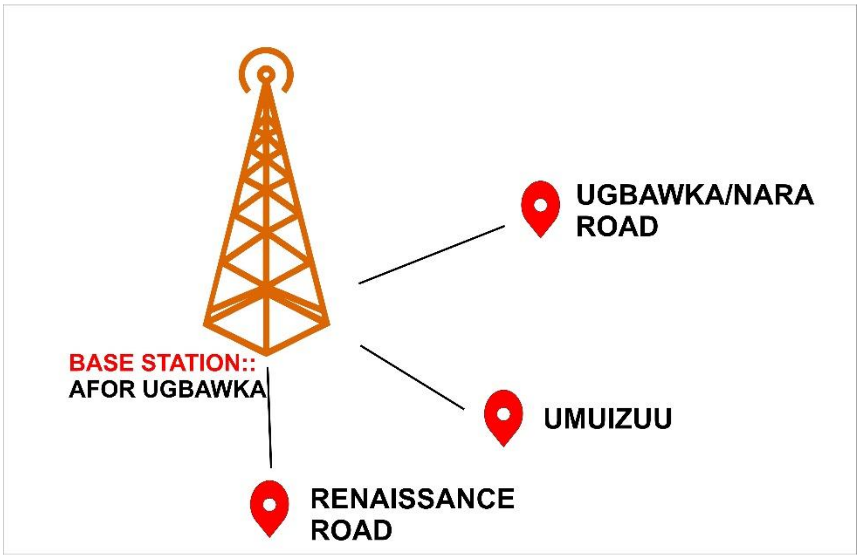


Figure 2.2. The base station and the three locations tested for internet availability

To know the impact of the network tower on the researcher's testbed, a pathloss measurement was carried out from the point of presence, (POP), towards the direction of the researcher's testbed, the Renaissance University. Unlike other measurements of lower frequencies that made use of an RF explorer, the network tower works on LTE frequency, using 2G (900MHz & 1800MHz) and 3G (2400MHz). The measurement was done using a computer-based LTE Drive Testing Software called TEMS Investigator 19.0. There are other older and latest versions of this software but the 19.0 has higher advantages for its easy-to-use and its ability to undertake both indoor and outdoor testing. In order to get the required results, an active cell had to be sectored. In this way, no other cell could cognitively handover signals to the cell being used. The drive test was conducted within a 1km at each of the three selected directions. For every 100m interval during the drive, measurements were carried out using the computer-based software, TEMS Investigator, 19.0. The setup for this measurement included a Laptop, an Inverter, which was connected to the Car's battery so as to convert DC to AC and to power the Laptop being used, and the three Samsung Android devices that provided 2G and 3G connectivity for the operations. Figures 2.3 and 2.4 show the path taken during the measurement exercise.

Figure 2.3 : Pathloss Propagation towards Renaissance University from the computer screen

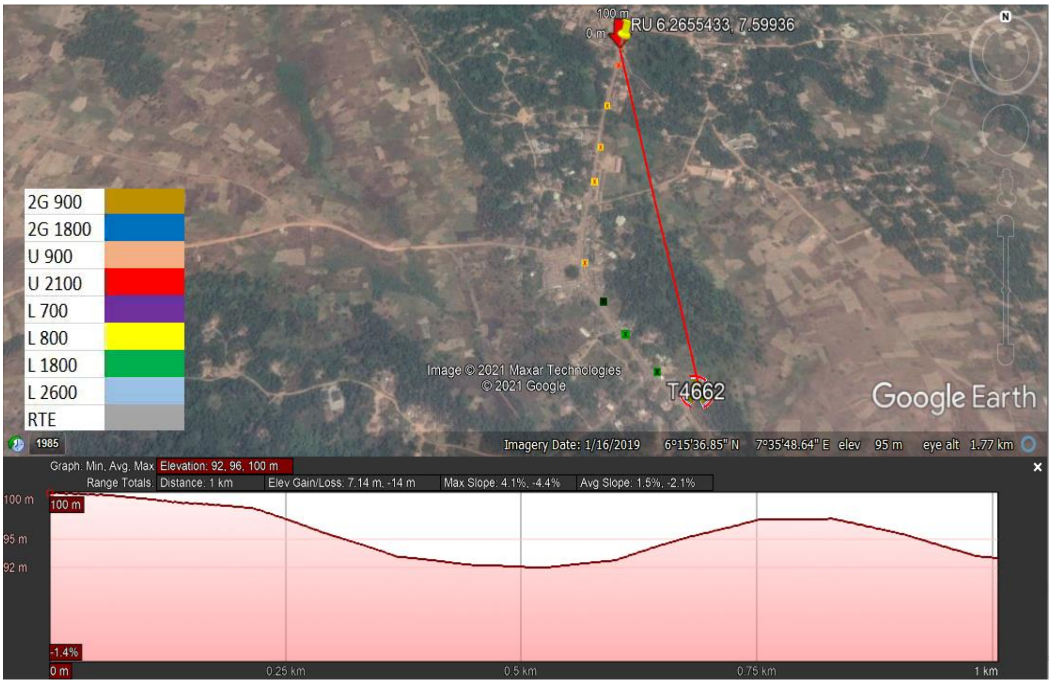


Figure 2.4: Google Earth Map showing elevation and distance from the POP P towards Renaissance University.

The Figure 2.4 shows the elevation of the MTN Tower Transmitter and a direct line of sight to the end of the 1km LTE Drive Test. It indicates the elevation details of objects, buildings and trees that could possibly attenuate the signal of the transmitter. According to the colour chart, its attenuation increased over the distances; stressing the need for TV White Spaces.

The testbed, Renaissance University, Ugbawka is characterized by an MTN Network tower with ID T4662, that can be found at Afor Ugbawka which is 4.82 km away from the Campus at exactly Lat 6.256647 Long 7.600204. The network tower antenna height is 22m with tower height of 70m and transmitter power of 40w.

To properly determine the effect of distance over the MTN network tower on the testbed and to also show the possible unavailability of network in the researcher's testbed, a pathloss propagation measurement that would show signal strengths of the MTN Network transmitter on its tower was carried out, 1km away from the network tower base in the direction of Renaissance University, Ugbawka and at two other two locations at Ugbawka, Umuizu and Umuanyi communities. As the distance increases, the signal strength decreases or the path loss increases.

2.2 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 2.5, 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 2.6 and 2.7 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

Figure 2.5 : Set Up for Frequency scanning.

Table 2.2 : 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

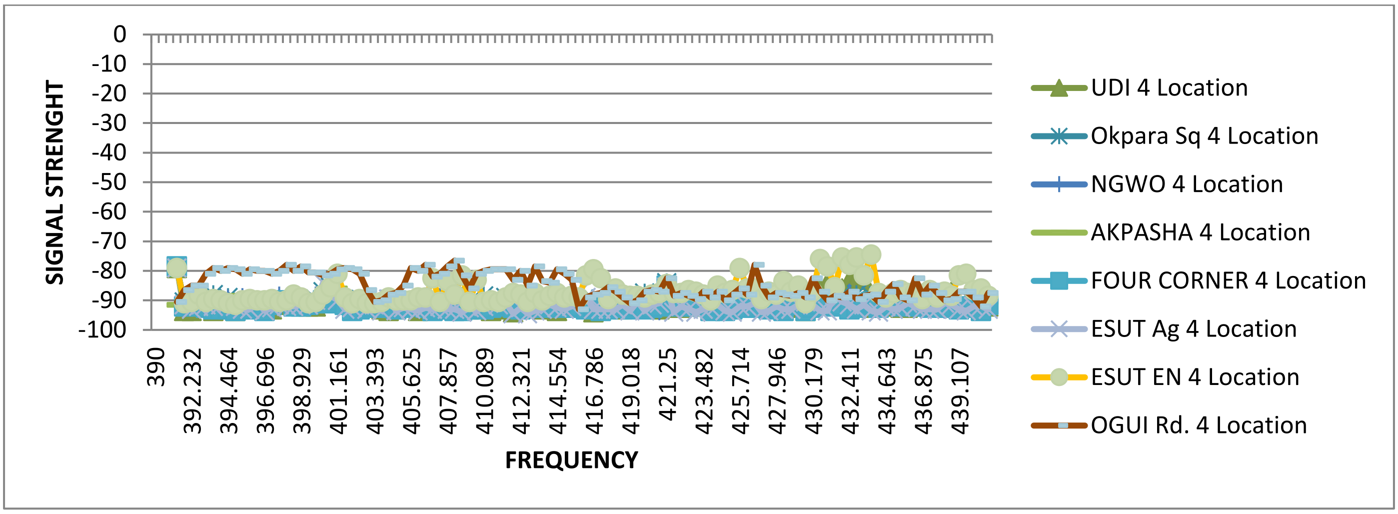


Figure 2.6 : Signal Strength Display through the Drive Routes

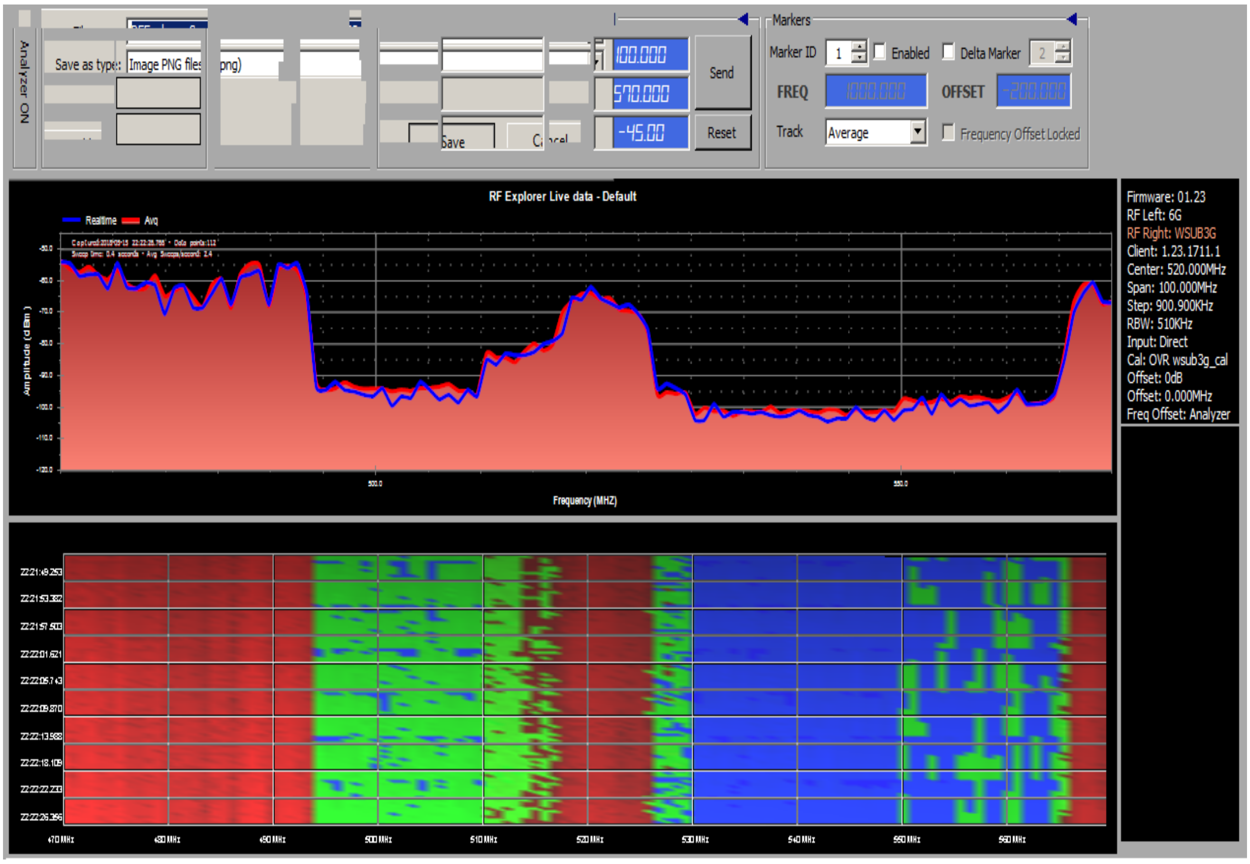


Figure 2.7 : RF Explorer Live Data Debug

The measurement results for Renaissance University as a typical rural chosen location, show that bands for terrestrial TV broadcast are free. According to National Frequency Management Council of Nigeria (NFMCN), among the bands observed are 240MHz - 265.4MHz, 305.1MHz and 306.9MHz are used for fixed mobile services. Bands from 310MHz - 430.1MHz which are used for STL Two-way radio (PMR)/ fixed mobile, Bands 451.1MHz, 469.9MHz, 470.8MHz and 470.3MHz are for STL: Private CDMA Networks Bands from 510.2MHz to 519.7MHz where signal was presence are used for Analog TV, DTT and DVB-TV. There is no transmission from band 520MHz to 740MHz. Appendix 1 shows the Table of Frequency allocation by National Frequency Management Council of Nigeria (NFMCN). Apart from 510.2MHz – 519.7MHz bands, the whole of the spectrum between 470MHz- 740MHz has power level below -107dBm.

2.3 Measurement of received signal strength of the network under study.

Spectrum studies clearly show the feasibility of using the White Spaces to allow secondary communication. Received signal strength (RSS) also known as the RSSI (received signal strength indicator) is a factor used in measuring the present power of received cellular communication radio signal of any choice. The received signal strength indicator is also a cellular radio technology receiver metric that are normally unseen to the cellular radio subscriber's device.

The measurements were carried out using the RF Explorer to obtain readings of the frequency using the computers to record the obtained values as depicted in figure 2.5 setup. Several days of measurements were conducted and the measurements taken between 2pm and 3pm each day for 5 working days, 2 days in August 2019 and 3 days in January, 2020 have been documented. The Frequencies had to be accessed at multiple periods under different conditions as the researcher was taking weather and climate changes under consideration since weather and structures have effects on Network propagation. Meanwhile, the Frequency Sensing measurements were consecutively taken at the frontage of the administrative block of the Renaissance University, Ugbawka on Latitude $6.33^{1}39.4^{11}$N and longitude $7.35^{1}54.3^{11}$E, then at the neighboring locations at Afor Ugbawka, Rail-crossing and at a rice farmland.

The RF Explorer repeatedly scanned the spectrum from 240 to 960 MHz for 1hour. The Windows-complaint Spectrum Analyzer embedded RF Explorer Application took the readings of the magnitude of the input. The results were published as CSV files for processing and analysis.

The RF explorer was set to scan only the UHF band of the Television Spectrum from 470MHz to 698MHz by connecting it to a Windows PC through the USB port. This provides for additional functionality using the "RF Explorer Windows PC Client" tool which supports Windows, Window 7 both 32 and 64 bits. The results were saved automatically by the RF Explorer on Excel sheet format.

The RF Explorer model WSUBIG was used in the measurement process. The model has a Nagoya NA-773 wideband telescopic antenna with vertical polarization with a wide band measurement capability of 240 MHz to 970 MHz. The windows PC client tool was installed on a laptop computer before connecting the RF explore to the computer to have additional functionality. The Figure 2.8 below shows a typical feature of the RF spectrum analyzer used.

Figure 2.8 : RF Explorer Spectrum Analyzer

This is RF Explorer model 3G Combo. It has seven functional buttons in the front side and one RF connector of 50 Ohms impedance standard. The unit will automatically start running on USB power when a compatible mini-USB cable is connected. The internal battery power switch is usually on the ON position for the battery to charge when the USB cable is connected to a laptop. The internal battery will not charge when the power switch is on the OFF position. It comes with a Nagoya NA-773 wideband telescopic and whip dipole antenna.

The Television White Space makes use of TV frequencies and in Enugu, there are two Television stations serving Enugu State. They are the Enugu State Broadcasting Service on Ultra High Frequency (UHF) and the Nigerian Television Authority on Very High Frequency (VHF).

The Enugu State Broadcasting Service (ESBS) has a EUROTEL type transmitter with its Tower location on Latitude 7.4541375^{o}N and longitude 6.4413274^{o}E. It Transmits on UHF CHANNEL 50. Its Rated Power has been 20KW while the ERP was 14kw but now has a 2kw transmitting power due to its relocation to the broadcast base at Independence Layout from the Hill-Top, Ngwo. The Antenna height is the height of the tower above the terrain. It is needed when calculating the propagation loss. So, its normal ANTENNA height is 60ft while the Tower Mast is 1000ft giving a Total of 1060ft high or 300 meters. The radiation pattern of the transmitting antenna is OMNI DIRECTIONAL. The population and area covered is the whole of Enugu State and beyond but can only be received at line-of-sight. The frequency at which it is transmitting is: VIDEO=703.25MHz, AUDIO=708.75MHz.

The Nigeria Television Authority data has a 10KW Rhodes Transmitter which is Schwarz liquid-cooled. Its Location is at Latitude 6^{0} North (6.4583^{0}N) Longitude 7^{0} East (7.4124) bearing Altitude 534.1 meters. Accuracy of measurement is 6.00 meters on NTA channel 8 (VHF) Band III. The transmitting Power or Effective Radiated Power is 10 KW. The antenna height above sea level for NTA Enugu Transmitter is 150 meters above ground level. Area of coverage when on optimal power includes Enugu, Anambra, Ebonyi and parts of Delta and Benue. The Transmitting Frequency is 196.25 MHz for Video and 201.75 MHz for Audio. Because this frequency is not within NCC approved TV White Space frequency, the ESBS transmitting station became useful for this experiment. These two TV stations' parameters are displayed in a tabular form using Table 3.7.

Table 2.3: The Two Transmitters Parameters

	Enugu State Broadcasting Service (ESBS) Enugu	**Nigeria Television Authority, (NTA) Enugu**
Transmitter Type	EUROTEL	10 KW Rhodes and Schwarz, liquid cooled Transmitter Analogue
Tower location	Latitude 6.4413°N and Longitude 7.4541°E	Latitude 6.4583°N and Longitude 7.4124° E bearing Altitude 534.1
Transmitting Channel	UHF Channel 50	VHF channel 8 on Band 111
Effective Radiated Power	ERP is 14 KW	ERP is 10 KW
Antenna Height above sea level	Antenna = 60 ft while the Mast = 1000 Total 1060ft	This is 150 meters above sea level
Radiation Pattern of the Transmit Antenna	Omni Directional	Isotropic Radiation
Population and area covered	Whole of Enugu and Surrounding States	Enugu, Anambra, Ebonyi and parts of Delta and Benue
Transmitting Frequency	Video = 703.25 MHz and Audio = 708.75 MHz	Video = 196.25 MHz and Audio = 201.75 MHz

Table 2.4: Typical reading during Ugbawka measurements

RF Explorer CSV data file: RFExplorer PC Client - Format v005

Start Frequency: 470MHZ

Step Frequency: 450.45KHZ

Total data entries: 515

Data points per entry: 112

Sweep	**Date**	**Time**	**Time(Milliseconds)**	**RSS at 470(MHz)**	**RSSat 490.45**	**RSS at 490.901**	**RSS at 491.351**	**RSS at 491.802**	**RSS at 492.252**
0	10/8/2019	14:33:36	0.775	-99.5	-102.5	-100	-100	-99.5	-101.5
1	10/8/2019	14:33:36	0.975	-104	-99.5	-101	-97.5	-100	-102.5
2	10/8/2019	14:33:37	0.165	-103	-104	-99	-101	-101.5	-96.5
3	10/8/2019	14:33:37	0.355	-98	-100	-100.5	-100.5	-99	-98.5
4	10/8/2019	14:33:37	0.555	-102.5	-100	-96.5	-100.5	-101.5	-101
5	10/8/2019	14:33:37	0.745	-103.5	-99	-99.5	-96.5	-100.5	-96.5
6	10/8/2019	14:33:37	0.945	-99.5	-100	-96.5	-100	-100.5	-103.5
7	10/8/2019	14:33:38	0.136	-99	-100.5	-103	-96.5	-98.5	-99.5
8	10/8/2019	14:33:38	0.326	-103	-101.5	-94.5	-102	-99	-97
9	10/8/2019	14:33:38	0.526	-99.5	-102	-99.5	-100.5	-103	-95.5
10	10/8/2019	14:33:38	0.716	-100.5	-99	-99.5	-103	-100.5	-104
11	10/8/2019	14:33:38	0.906	-100.5	-98.5	-100.5	-100.5	-98.5	-96.5
12	10/8/2019	14:33:39	0.106	-97.5	-102	-98.5	-102	-98.5	-100.5

13	10/8/2019	14:33:39	0.317	-96.5	-101.5	-101	-104	-103.5	-102.5
14	10/8/2019	14:33:39	0.486	-97.5	-104	-102	-101.5	-97.5	-97.5
15	10/8/2019	14:33:39	0.686	-101	-96	-103	-100.5	-103.5	-98
16	10/8/2019	14:33:39	0.876	-101.5	-97.5	-98	-97.5	-100.5	-99.5
17	10/8/2019	14:33:40	0.076	-100.5	-101.5	-99	-99.5	-101.5	-104
18	10/8/2019	14:33:40	0.266	-100.5	-98	-99	-98.5	-100	-101
19	10/8/2019	14:33:40	0.458	-100.5	-100.5	-97.5	-100	-102.5	-102.5
20	10/8/2019	14:33:40	0.648	-99.5	-99	-103	-98.5	-98	-101.5
21	10/8/2019	14:33:40	0.849	-100.5	-99.5	-97	-98	-100.5	-101.5
22	10/8/2019	14:33:41	0.039	-97	-99.5	-101.5	-100	-103	-102
23	10/8/2019	14:33:41	0.229	-97.5	-99.5	-100.5	-99	-98	-101
24	10/8/2019	14:33:41	0.43	-97	-104	-97.5	-100.5	-102.5	-101.5
25	10/8/2019	14:33:41	0.625	-101	-101	-100	-96.5	-99.5	-101.5
26	10/8/2019	14:33:41	0.815	-104	-99.5	-99	-102	-104	-98.5
27	10/8/2019	14:33:42	0.005	-101.5	-98.5	-102	-99	-99	-100
28	10/8/2019	14:33:42	0.205	-104	-103	-100	-99.5	-97	-98
29	10/8/2019	14:33:42	0.395	-102	-102	-98.5	-104	-100.5	-99.5
30	10/8/2019	14:33:42	0.585	-100	-104	-98	-100.5	-99.5	-102.5
31	10/8/2019	14:33:42	0.785	-99	-101	-100	-98.5	-95.5	-96.5
32	10/8/2019	14:33:42	0.975	-99	-100	-101	-99	-99	-100.5

2.4 Community Spectrum Access System/ Network Planning

It is only fair that the way citizens access the database is demonstrated at this point. Currently, most of the Internet Service Providers connect urban users through a fiber mode. For the deployment of TVWS, a Spectrum Access System database is set up to control the way the TVWS bands are accessed avoiding interferences of any primary User. The Figure 2.8 demonstrates areas this community can enjoy facilities when internet connected.

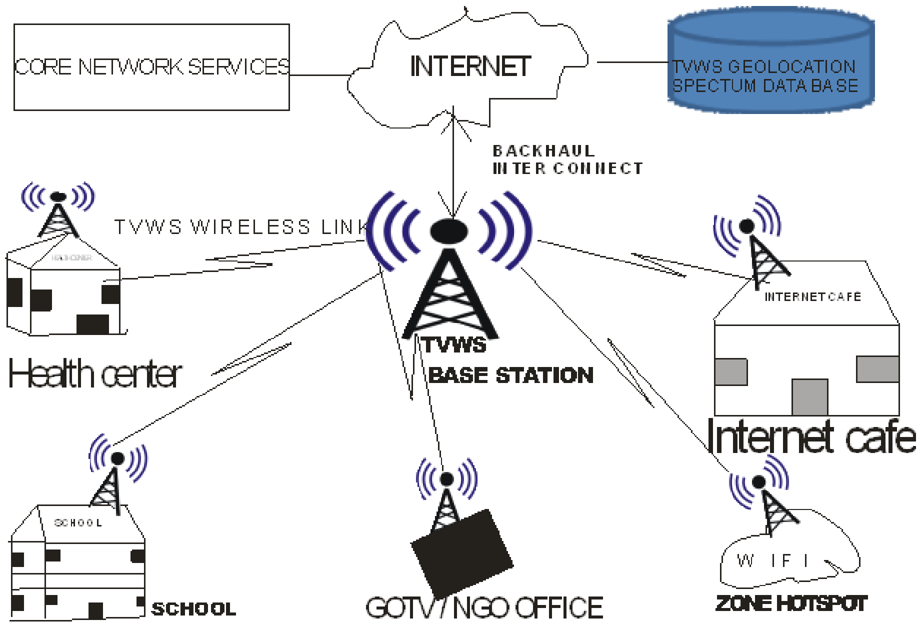
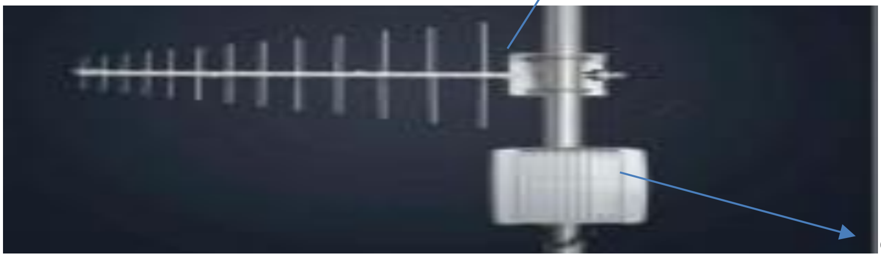


Figure 2.8 *Community Spectrum Access System*

A network planning is performed by first establishing that this is a fixed wireless broadband network working through opportunistic use of TVWS. The requirement for coverage and capacity while taking into accounts the radio propagation characteristics of Ugbawka area as a typical rural community is depicted in figure 2.8. Through the characterization/evaluation of this testbed, already performed by this project, a frequency planning followed suit to establish the dire need of TVWS. The RF survey by the above characterization of the testbed, identified some TVWS channels at this service area. Carlson Radio Antenna is a good TV Tool, as in the Figure 2.9, used to indicate which channels will work better in the community.

Antenna



Carlson Radio

Figure 2.9*: Typical antenna and Radio mounted for community connectivity*

This Spectrum Access System is a cloud-based service which will manage the wireless communications of devices transmitting in the community Broadband radios, like the Customer Premise Equipment (CPEs) as in Figure 2.8. A Community Broadband Radio Service Device will require authorization from the Community Spectrum Access Service before it starts to transmit in the community Broadband Radio Service band. With an Omni-directional Antenna as depicted in Figure 2.9, a good community wireless service is achieved as in Figure 2.8. The Carlson wireless device has the capacity to check the connections to Spectrum Management Database (SMDB) regularly. The developed database in the course of this project will provide the list of available TVWS channels based on the location of the Base station.

III. CONCLUSION

The provision of wireless broadband internet to this unconnected or poorly connected rural area is foreseen to be one of the key applications that will use TV White spaces technique. The high cost of installing optical fiber in remote locations, makes it imperative that a cost effective wireless solutions as TV White space technology must be found to ensure higher internet penetration especially in the remote locations of Nigeria. A network latency measurement was taken at the testbed in Ugbawka on three internet providers with an average round trip of 846.433ms on MTN network, 537.1 ms on AIRTEL and zero result for the GLO, showing absence or near absence of internet in the area.

An extensive field measurement was carried out to model and simulate the available frequencies while a scheduling technique which was created would help towards the opportunistic broadband connectivity in the rural areas. The measurement was specifically used to determine the level of signal penetrations, using Enugu State Broadcasting Service (ESBS) Transmitting on channel 50, and on frequency 703.25MHz. The Received Signal Strength, throughput, latency, Delay and Signal to-Noise-Ratio were ascertained from the measured results. The frequency sweep exercise that employed the use of an RF Explorer was used to measure these values on the Ultra High Frequency (UHF) band of the Television spectrum between (470 – 790 MHz).

IV. REFERENCES

[1]. Amritha, R., Anjali, T., Aswathylakshmi, P., Greeshma, V., and Sudha, T. (2015). TV WHITE SPACE DETECTION USING USRP. Journal of Theoretical and Applied Information Technology., 82(3), 353–359.

[2]. Aneja, B., Sharma, K., and Rana, A. (2019). Spectrum sensing techniques for a cognitive radio network. Lecture Notes in Electrical Engineering, 509, 133–144. https://doi.org/10.1007/978-981-13-0665-5_11

[3]. Arkoulis, S., Kazatzopoulos, L., and Marias, G. F. (2014). Cognitive Spectrum and its Security Issues. January 2008. https://doi.org/10.1109/NGMAST.2008.102

[4]. Atimati, E. E., Ezema, L. S., Ezeh, G. N., Iwuchukwu, U. C., and Agubor, C. K. (2015). A Survey on the Availability of TV White Spaces in Eastern Nigeria (FUT Owerri, As Case Study). 6(12), 609–614.

[5]. Baykas, T., Kasslin, M., Cummings, M., Kang, H., Kwak, J., Paine, R., Reznik, A., Saeed, R., and Shellhammer, S. J. (2012). Developing a standard for TV white space coexistence: Technical challenges and solution approaches. IEEE Wireless Communications, 19(1), 10–22. https://doi.org/10.1109/MWC.2012.6155872

[6]. Centre, T. E. (2014). Broadband deployment through TV - White Space (Telecommunication Engineering Centre (ed.); p. 18). http://tec.gov.in/pdf/Studypaper/TVWS_Final.pdf

[7]. Ezeagwu, C. O., Azubogu, A. C., Okeoma, S. C., and Obi, C. A. (2016). Improving Spectrum Management In Nigeria With Respect To The Best Practices In The World. International Journal of Advanced Research in Computer Engineering and Technology (IJARCET), 5(10), 2508–2514.

[8]. Ezeji, N. G., Azubogu, A. C. ., Nwobodo, N., and Harmony, N. (2020). Design And Development Of A Web Based Geolocation Database For The Television White Spectrum (Tvws) In Nigeria . 2(10), 26–39.

[9]. Fanan, A. M., Riley, N. G., Mehdawi, M., and Alfahad, O. (2017). Performance of a TV white space database with different terrain resolutions and propagation models. Telfor Journal, 9(2), 80–85. https://doi.org/10.5937/telfor1702080f

[10]. Gomez, C. (2013). GSR 2013 Discussion Paper, TV White Spaces: Managing Spaces or Better Managing Inefficiencies ? July, 3–5. http://www.itu.int/en/ITU-D/Conferences/GSR/Documents/GSR_paper_WhiteSpaces_Gomez.pdf

[11]. Government of Nigeria. (2013). Nigeria ' s National Broadband Plan. http://commtech.gov.ng/index.php/videos/news-and-event/147-nig-national-broadband-

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