Design and Implementation of Geo-Location Database for TV White Space in Edo State, Nigeria

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***Abstract*-This research focuses on the design and implementation of the first Television White Space (TVWS) Geo-location database for Edo State, Nigeria that is capable of calculating and availing the amount of unused frequencies channels at any given location and time of the day. The sensing technique was used for comprehensive quantitative estimation of TVWS in the 470-870MHz of the Ultra High Frequency (UHF) band, using an inexpensive Radio Frequency (RF) spectrum analyzer. The database was developed using laragon server and the results from the sensing were imported into it systematically and is released for public access. The result analysis show that of a total number of the TV channels allocated to the TV stations in urban area 66% is occupied while 34% was not occupied, in semi-urban area 50% is occupied while 50% was not occupied and in rural area only 8% is occupied while 92% is free to be used by White Space Device (WSD). White space devices can query the database via the internet with the help of a hypertext preprocessor (PHP) script designed to handle the logic used to analyze, calculate and avail TVWS channels once the device has indicated its location and time. The result from the query guides the WSD on its choice of frequency channel to transmit over during opportunistic access. This plays a decisive role in protecting the primary users from interference which are the rules for TVWS communication technology.**

***Keywords:* Geo-location, Database, TVWS, Edo State, Ultra High Frequency (UHF), White Space Device (WSD).**

I. INTRODUCTION

Transition to the Digital Television (DTV) has freed up large spectrum bands, known as a digital dividend: these frequencies are now available for opportunistic use and referred to as Television White Space (TVWS). "TV White Spaces" which is defined as: TV channels that are not used by any licensed services at a particular location and at a particular time [1]. TVWS propagation characteristics are good for wireless communication. Secondly very little and relatively cheap infrastructure is required for their implementation, making them suitable for rural and undeveloped areas [2]. The release of TVWS came at the right moment since frequencies allocated for mobile cellular networks, industrial, scientific and medical radio band (ISM) became highly congested while demand for mobility and wireless communication keeps on increasing at an exponential pace [3]. When we investigate actual usage, quite a small fraction of allocated spectrum is really in use [4]. One way to get more spectrum would be a fundamental revision of the regulations, which is not a feasible task. Another is to open access to licensed spectrum for other users, as long as they do not generate interference to incumbent license owners. The latter approach is known as Dynamic Spectrum Access (DSA), and it provides a set of spectrum access techniques enabling mutual coexistence in the opportunistic environment. DSA was a natural choice for TVWS regulatory framework. The unlicensed usage of TV white spaces, which refers to the unused portions of the UHF spectrum, and parts of the VHF spectrum in the US, has been regulated by the FCC as a means to support the mobile users' ever increasing demand for high quality communication and multimedia streaming [5]. The ruling ensures the mitigation of interference amid spectrum incumbents and White Space Devices (WSDs) by enforcing WSDs to use either spectrum sensing or geo-location databases. Following the former method, WSDs use white spaces after sensing the spectrum for TV transmissions with a very low threshold of -114 dBm. Spectrum sensing capabilities add complexity and cost complications to WSDs, especially with this low threshold. The latter method relies on consulting a geo-location databases that keep track of available white spaces in certain areas [5] by maintaining a record of TV transmitter information such as; location, antenna height, transmitted power, and channels used. Geo-location databases utilize this information with sophisticated propagation models in order to determine the protection area of a TV transmitter, where no WSD can be active [6]. This approach is currently the preferred approach for detecting white spaces by several regulators (e.g. FCC, Ofcom and ECC) [7]. Fig.1. Depicts the architecture of a simple white space network based on geo-location database.

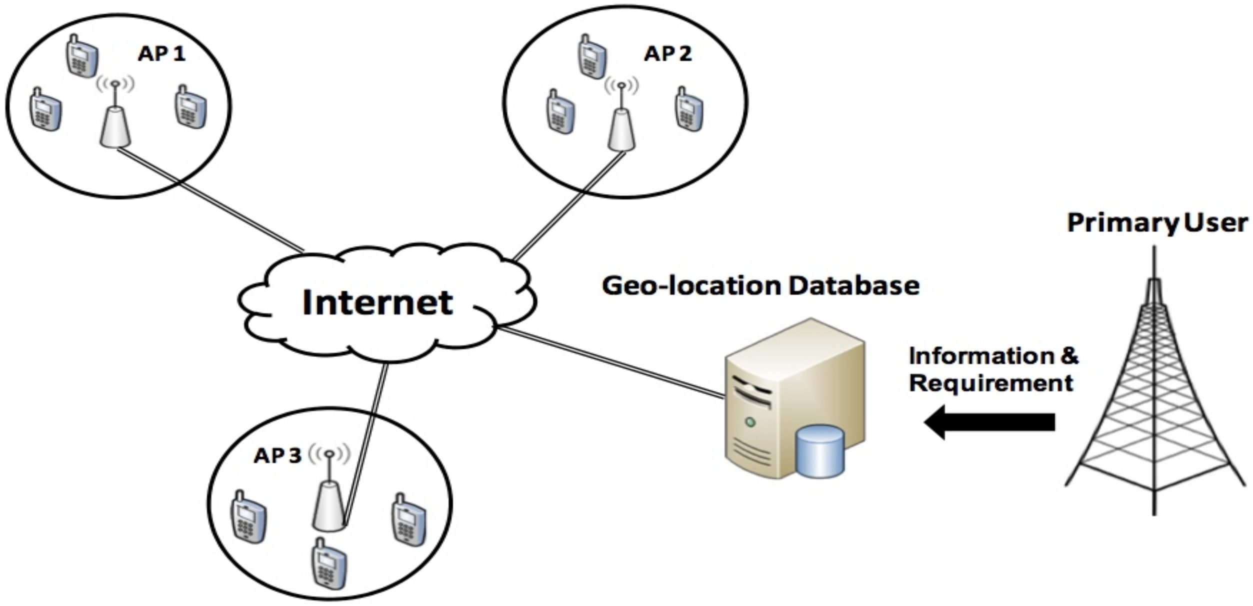


Fig. 1 Simple White Space Network Based on Geo-location Database Architecture [8].

TV whitespace (TVWS) varies with location and it is time specific, which makes it difficult to obtain accurate information on which frequencies are been occupied by primary licensed users and those that are vacant for secondary usage as these factors play a fundamental role in protecting the primary users from interference. The rules are that Secondary Users must never cause interference to Primary users; this is the central problem for efficient and safe utilization of TVWS spectrum. This research aims to design and implement a Geo-location database for Television white space Network in Edo State, Nigeria that is capable of calculating and availing TVWS channels for the secondary users in the UHF TV bands (470-870MHz) at any specified location and time without causing interference to the primary users.

The rest of the paper is structured as follows: Section II presents a review of related works on Geo-location database widely accessible; Section III describes the method of data collection employed. Data presentation and results are presented in Section IV. We conclude the paper in section V by highlighting the main findings of the paper.

II. LITERATURE REVIEW

2.1 Review of Related Works

The Federal Communications Commission (FCC) is now actively formulating policy and regulations for dynamic spectrum access. The most recent FCC ruling requires that secondary TV spectrum users (i.e., whitespace devices) must rely on a geo-location database to determine the spectrum availability [9].

Database administrators have also been appointed by the FCC and early services to help identify white spaces which have been launched by Spectrum Bridge in 2014.

Ofcom in its public consultation process is supporting geo-location database for WSDs and several TVWS pilot projects have been conducted in the United Kingdom (UK) and Singapore under the supervision of spectrum regulators utilizing a geo-location database scheme [10], [11]. The conducted studies were specifically designed to validate certain technical solutions for TVWS database analysis, which leverage propagation models for better efficiency and performance. The key function of the geo-location database is to ensure the protection of incumbent users.

Gurney et al. (2008), presented the design of a geo-location database for white spaces networking, their system computed the available white spaces based on the transmit power of the white space device and without using terrain information. They presented a limited evaluation in the Chicago area.

Harada H. (2012), developed a white space database for Japan, National Institute of Information and Communications Technology (NICT) based on FCC rules, since rules for TV white spaces operation in Japan are still under discussion. Their system computed the available white spaces based on antenna height of the white space device and without carrying out spectrum measurement of geo-location.

The Council for Scientific and Industrial Research (CSIR) (2013), at Meraka Institute of South Africa also developed a Geo-location Spectrum Database, which is available online. Their system computed the available white spaces based on the transmit power of the white space device only; the limitation of this work is that no spectrum measurement of geo-location was carried out.

Telcordia (2014), (now iConectiv) designed a TV White Space database on the 8th October 2014, for Scott city of Louisiana, United states, Their system also computed the available white spaces based on the transmit power of the white space device and antenna height and but it has a limitation of not carrying out spectrum measurement of geo-location.

Fair spectrum (2014), also designed a database on the 10th June 2014 for Orkney Islands in Scotland in the UK and Also for Turku, in Finland but both did not consider spectrum measurement of geo-location. Nominet (2014) also built a Geo-location data base on the 10th June 2014 for Oxford city of England in United Kingdom.

Spectrum Bridge inc. (2014), also released a web site on the 21st May 2014, called Show My White Space that depicts the white spaces available around Watford City of Hertfordshire in the United Kingdom, their system computed the available white spaces based on the transmit power of the white space device only and without terrain information

Google (2017), also developed a white space database called spectrum database on the 4th September 2017 for Kansas, Alabama and Las Vegas region in the United States which is available online. Their system also computed the available white spaces based on the transmit power of the white space device and antenna height but without carrying out spectrum measurement of geo-location.

III. METHODOLOGY

3.1 Measurement Environment and Data Collection

The UHF spectrum was measured across three different locations in Edo State, South-South Region of Nigeria. The Spectrum measurements campaigns were carried out during the months of December 2017, January and February 2018 for the three different locations repeatedly. Fig. 2 and table 1 depict the Google map and the locations where spectrum measurement campaign was carried out alongside their co-ordinates.

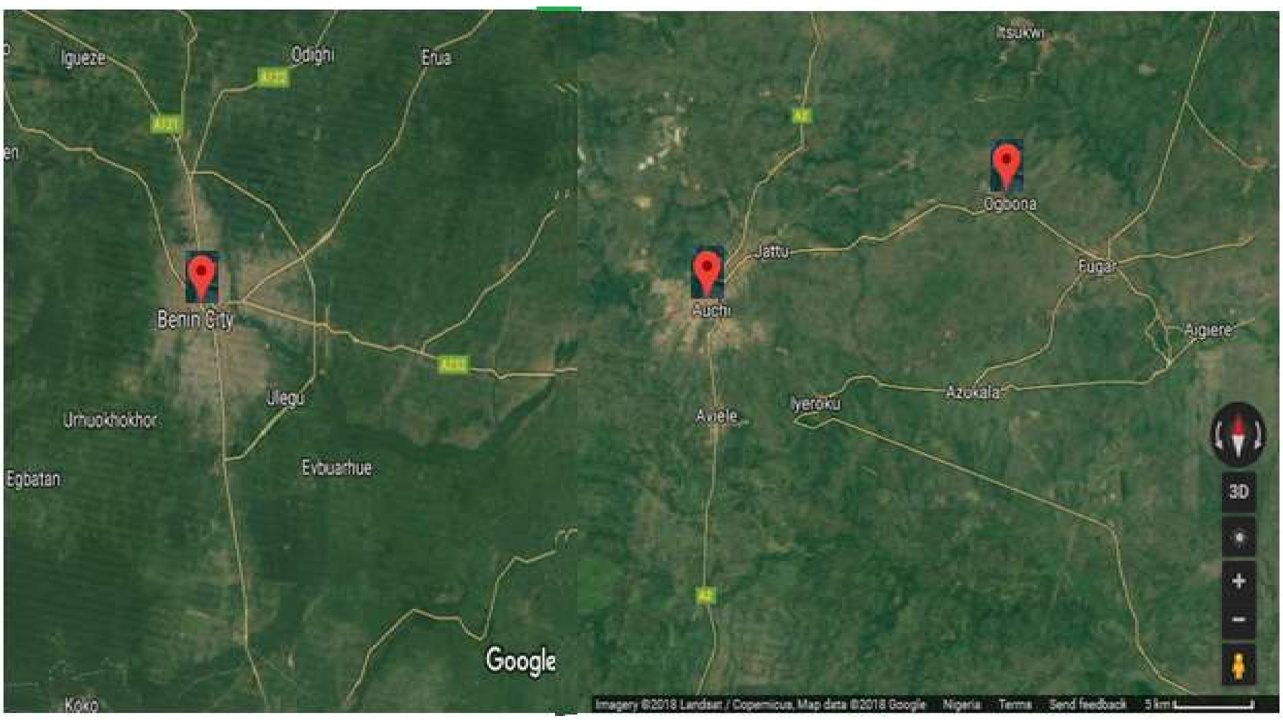


Fig. 2: Google Map of the Measured Locations. (Courtesy: Google Earth)

Table 1: Co-Ordinates of the Measured Locations

S/no	Site Name	Latitude	Longitude
1.	Aduwawa (Urban Area)	6.33918	5.61744
2.	Auchi (Semi-urban Area)	7.0669	6.2748
3.	Ogbona (Rural area)	7.1074	6.4450

3.2 NBC Licensed Stations in Edo State

The Table 2 shows the licensed TV station signal, their channels and frequency of operation that can be received within the study area.

Table 2: TV Stations Parameters In Edo State

S/no	Station	Channel	Frequency
1.	Edo Broadcasting Station	55	743.25MHz
2.	Independent Television	22	479.25MHz
3.	Silver Bird Television	30	543.25MHz
4.	NTA Iruekpen	45	663.25MHz
5.	NTA Benin	7	189.25 MHz
6.	NTA Uzairue	41	631.25MHz

Spectrum measurements were taken using the spectrum analyzer to measure the received signal strength for all the 50 UHF channels (21 through 70) corresponding to 470-870MHz for 24 hours duration with an Omni-directional antenna, a laptop equipped with touchstone RF spectrum Analyzer software (RF explorer 3G combo model), Mini USB cable, and a Global Positioning System (GPS) Receiver set. The RF explorer antenna height is 1.5 meters above the ground, a span of 100MHz was used to enhance the visibility of the spectrum measured and the resolution bandwidth in the experiments was set to 178.57 KHz on the RF Explorer window client.

3.3 Designing and Building the Geo-Location Database

The water fall development method was adopted in the development of the web application that consists of user interface with form elements, using Hypertext Preprocessor (PHP), Hyper Text Markup Language (HTML), Cascaded style sheet (CSS), MySQL (Relational Database Management System) on laragon server and the frameworks used include bootstrap, laravel and Google map Api.

3.4 Program Design of Geo-location Database

The design of the geo-location database consists of the frontend and backend design.

Front End Design

The pseudo-code shown in fig. 3 illustrates the front end of the program design

```
Initialize the result variable according to the result gotten from the back end
Loop:
    If result is empty return
    If current channel is contained in the result, color green else, color white
    Display the current location on the map
    End loop
Display table
```

Fig. 3: Front-End of the Geo-Location Database

Back End Design

The pseudo-code shown in fig. 4 illustrates the backend of the program design

```
Initialize transmitter power and threshold variable
    Get users input for location, time and co-ordinates
    Process users request according to input
    Calculate received power
    Select all channels greater than threshold for that specific time from the database
Send result to front end
```

Fig. 4: Back-End of the Geo-Location Database

3.5 System Execution Methodology

The software main flow charts showing the system execution flow sequence is shown in fig. 5

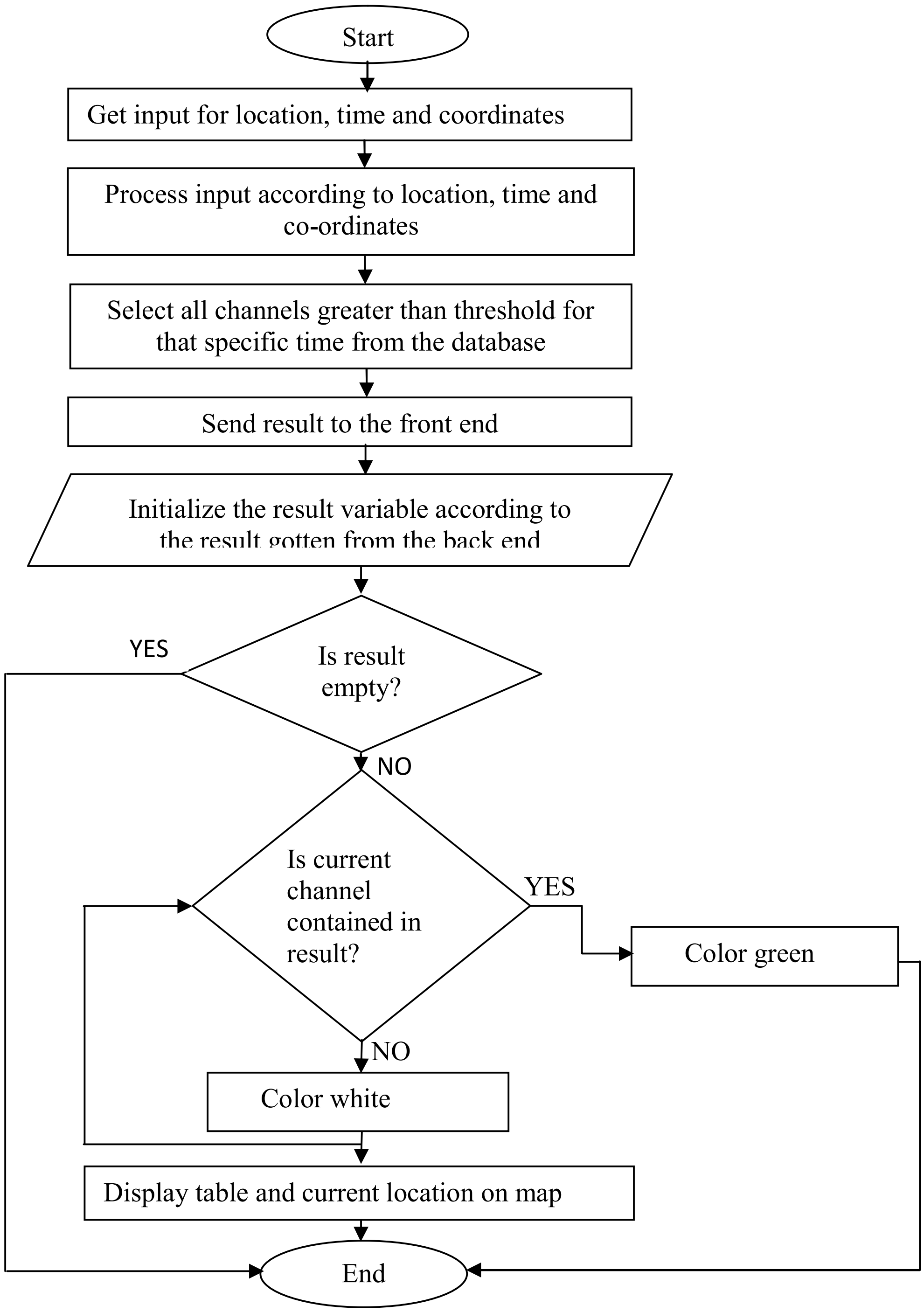


Fig. 5: Flowchart Showing System Execution Flow Sequence

3.6 Methodology for Calculation of Available Channels

The major aim of the system is to compute available channels with high accuracy and then store all available channels of each pixel in the database, in a way which makes it easy to retrieve the data from WSDs. All of the transmitter characteristics, such as Antenna height, transmitted power and channels are stored previously in the database. The process takes into account all channels of the selected transmitters that might be received in a specific pixel, taking into consideration the weak signals as well [18]. Once the power that reaches the pixel location is known, the easiest or simplest way to determine the available white spaces is to use a threshold: If the power in the location is lower than this threshold, the channel will be considered to be free. Otherwise, when the power is higher than the threshold, the channel will be classified as occupied. This process relies on computations that take into account proximity to licensed transmitters and receivers, specific transmitter types (e.g., full-power digital TV, low-power analog TV, low-power digital TV, etc.), and specific receiver interference protection requirements (e.g., on the co-channel, adjacent channel, etc.) to avoid harmful interference.

Transmit towers, secondary licensed users and WSDs (in case that they are registered) that are using a channel in a pixel have to be taken into account when calculating the available channels. Even if the update periods are not determined yet, it seems logical that the licensed user calculations should not be updated very often while the updates related to WSDs should be done more frequently because they will vary more frequently. The Database

Manager, apart from getting the required information from the stored data, will also contact the TVWS database when a public user queries for the available channels in a location.

IV. RESULTS AND DISCUSSION

4.1 Implementing the TVWS Geo-location Database

In this research work, the design and implementation of a geo-location database for the identification of television white space in Edo State, Nigeria was developed and the implementation is successfully able to decide whether a channel is occupied or free. Measurements using RF explorer revealed that the ambient noise level in the absence of any transmission channel occupied by a primary user is -114dBm to -97dBm. This was confirmed through repeated measurements in a known channel which normally ends transmission at 12:00am in the morning and the transmitter is shut down. i.e. Edo Broadcasting Service (EBS) TV that transmits on 743.25MHz. it has a signal presence of -57dBm to -85dBm when the transmitter is powered on and active transmission is ongoing. -97dBm was chosen as the noise threshold for the measurement to determine occupancy and un-occupancy of a channel.

Fig. 6 depicts the database structure adopted for this work in laragon server environment for the three locations (Auchi, Benin and Ogbona) where spectrum measurements were carried out. The scan results were recorded for 24 hours with a total of 448 entries. This corresponds to scan results taken at every 1hour interval.

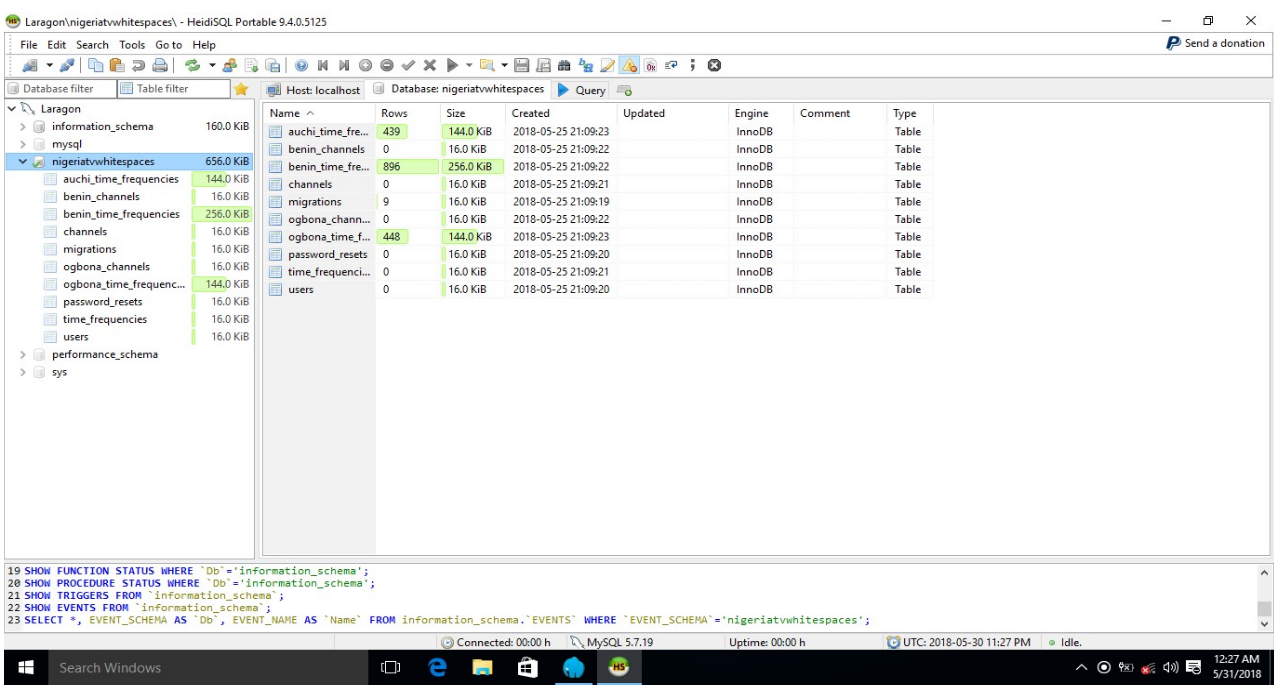
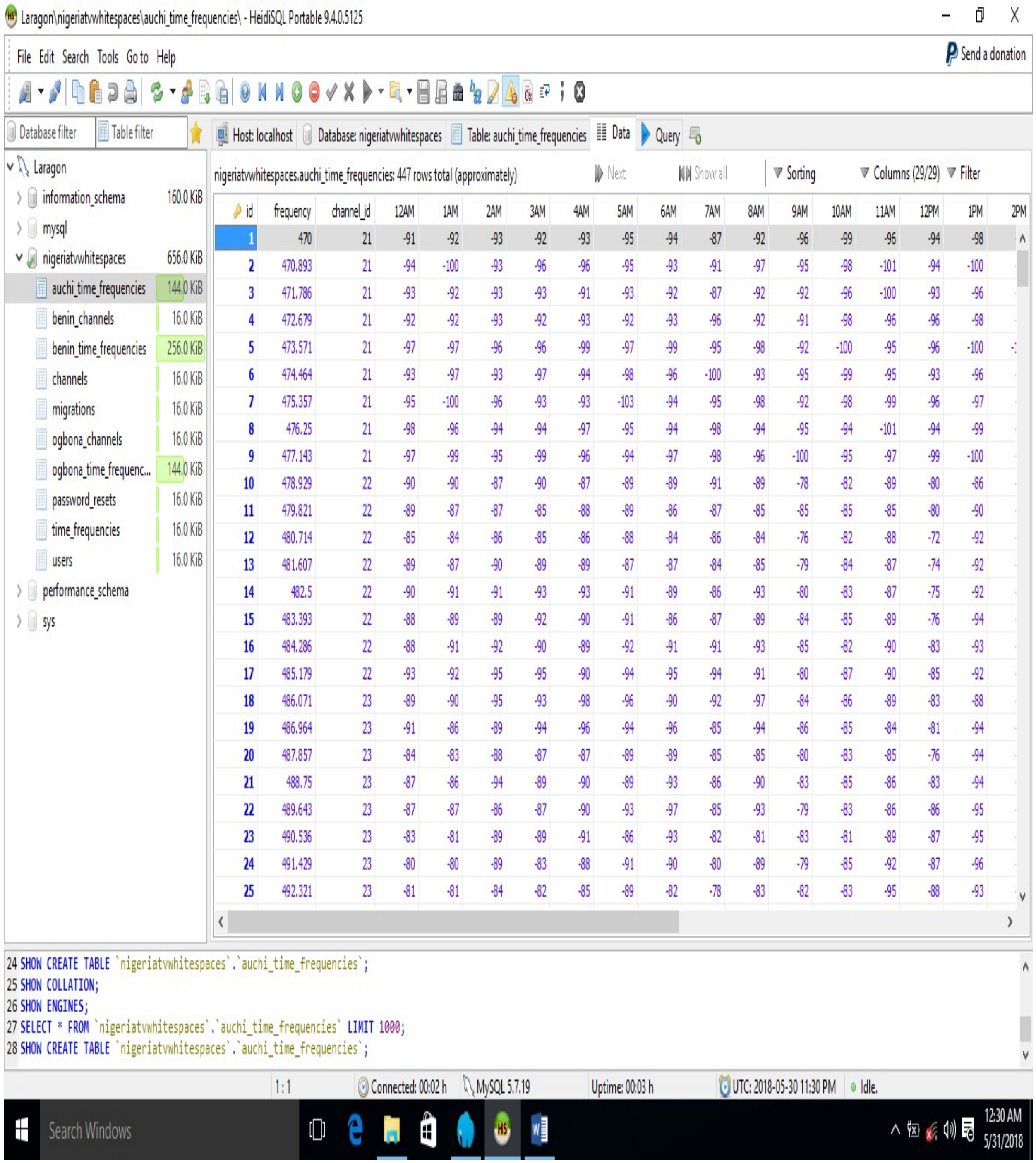


Fig. 6: Database Structure Adopted In Laragon Server Environment

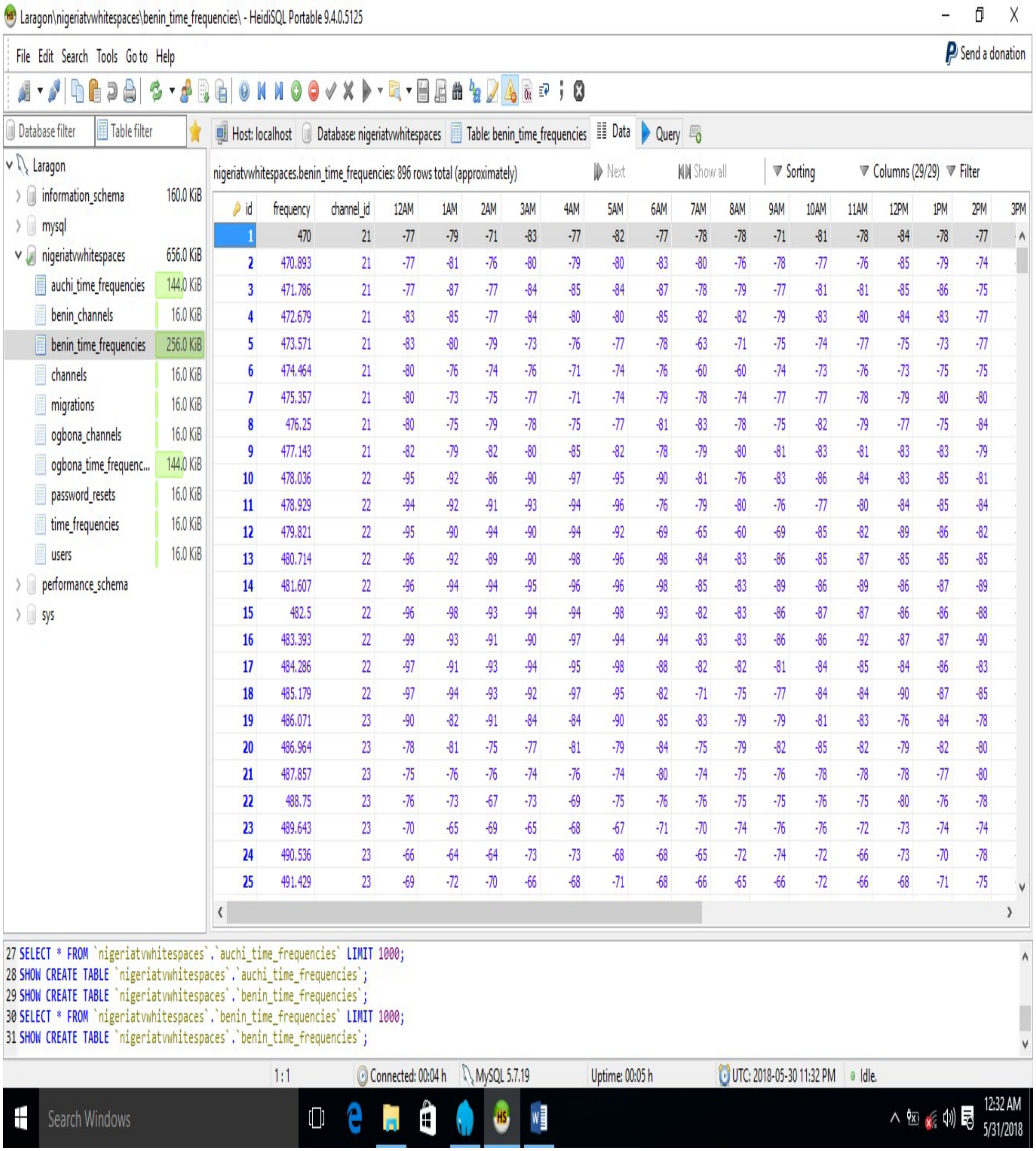
Fig. 7 depicts the database structure in laragon server environment and Nigeria TV whitespaces has been chosen as the database name where Auchi time frequency has been selected and it depicts the frequencies from 470 – 870MHz, their channel I.D and the scan results which were recorded from 12:00am mid night for 24 hours with a total of 447 entries. This corresponds to scan results taken at every 1hour interval.



id	frequency	channel_id	12AM	1AM	2AM	3AM	4AM	5AM	6AM	7AM	8AM	9AM	10AM	11AM	12PM	1PM	2PM
1	470	21	-91	-92	-93	-92	-93	-95	-94	-87	-92	-96	-99	-96	-94	-98	
2	470.893	21	-94	-100	-93	-96	-96	-95	-93	-91	-97	-95	-98	-101	-94	-100	
3	471.786	21	-93	-92	-93	-93	-91	-93	-92	-87	-92	-92	-96	-100	-93	-96	
4	472.679	21	-92	-92	-93	-92	-93	-92	-93	-96	-92	-91	-98	-96	-96	-98	
5	473.571	21	-97	-97	-96	-96	-99	-97	-99	-95	-98	-92	-100	-95	-96	-100	
6	474.464	21	-93	-97	-93	-97	-94	-98	-96	-100	-93	-95	-99	-95	-93	-96	
7	475.357	21	-95	-100	-96	-93	-93	-103	-94	-95	-98	-92	-98	-99	-96	-97	
8	476.25	21	-98	-96	-94	-94	-97	-95	-94	-98	-94	-95	-94	-101	-94	-99	
9	477.143	21	-97	-99	-95	-99	-96	-94	-97	-98	-96	-100	-95	-97	-99	-100	
10	478.929	22	-90	-90	-87	-90	-87	-89	-89	-91	-89	-78	-82	-89	-80	-86	
11	479.821	22	-89	-87	-87	-85	-88	-89	-86	-87	-85	-85	-85	-85	-80	-90	
12	480.714	22	-85	-84	-86	-85	-86	-88	-84	-86	-84	-76	-82	-88	-72	-92	
13	481.607	22	-89	-87	-90	-89	-89	-87	-87	-84	-85	-79	-84	-87	-74	-92	
14	482.5	22	-90	-91	-91	-93	-93	-91	-89	-86	-93	-80	-83	-87	-75	-92	
15	483.393	22	-88	-89	-89	-92	-90	-91	-86	-87	-89	-84	-85	-89	-76	-94	
16	484.286	22	-88	-91	-92	-90	-89	-92	-91	-91	-93	-85	-82	-90	-83	-93	
17	485.179	22	-93	-92	-95	-95	-90	-94	-95	-94	-91	-80	-87	-90	-85	-92	
18	486.071	23	-89	-90	-95	-93	-98	-96	-90	-92	-97	-84	-86	-89	-83	-88	
19	486.964	23	-91	-86	-89	-94	-96	-94	-96	-85	-94	-86	-85	-84	-81	-94	
20	487.857	23	-84	-83	-88	-87	-87	-89	-89	-85	-85	-80	-83	-85	-76	-94	
21	488.75	23	-87	-86	-94	-89	-90	-89	-93	-86	-90	-83	-85	-86	-83	-94	
22	489.643	23	-87	-87	-86	-87	-90	-93	-97	-85	-93	-79	-83	-86	-86	-95	
23	490.536	23	-83	-81	-89	-89	-91	-86	-93	-82	-81	-83	-81	-89	-87	-95	
24	491.429	23	-80	-80	-89	-83	-88	-91	-90	-80	-89	-79	-85	-92	-87	-96	
25	492.321	23	-81	-81	-84	-82	-85	-89	-82	-78	-83	-82	-83	-95	-88	-93	

Fig. 7: Auchi Time Frequency (Semi-Urban Area) In Largon Server Environment

Fig. 8 shows the database structure in laragon server environment and Nigeria TV whitespaces has been chosen as the database name where Benin time frequency has been selected and it depicts the frequencies from 470 – 870MHz, their channel I.D and the scan results which were recorded from 12:00am mid night for 24 hours with a total of 896 entries because of the presence of much signal. This corresponds to scan results taken at every 1hour interval.



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2	470.893	21	-77	-81	-76	-80	-79	-80	-83	-80	-76	-78	-77	-76	-85	-79	-74	
3	471.786	21	-77	-87	-77	-84	-85	-84	-87	-78	-79	-77	-81	-81	-85	-86	-75	
4	472.679	21	-83	-85	-77	-84	-80	-80	-85	-82	-82	-79	-83	-80	-84	-83	-77	
5	473.571	21	-83	-80	-79	-73	-76	-77	-78	-63	-71	-75	-74	-77	-75	-73	-77	
6	474.464	21	-80	-76	-74	-76	-71	-74	-76	-60	-60	-74	-73	-76	-73	-75	-75	
7	475.357	21	-80	-73	-75	-77	-71	-74	-79	-78	-74	-77	-77	-78	-79	-80	-80	
8	476.25	21	-80	-75	-79	-78	-75	-77	-81	-83	-78	-75	-82	-79	-77	-75	-84	
9	477.143	21	-82	-79	-82	-80	-85	-82	-78	-79	-80	-81	-83	-81	-83	-83	-79	
10	478.036	22	-95	-92	-86	-90	-97	-95	-90	-81	-76	-83	-86	-84	-83	-85	-81	
11	478.929	22	-94	-92	-91	-93	-94	-96	-76	-79	-80	-76	-77	-80	-84	-85	-84	
12	479.821	22	-95	-90	-94	-90	-94	-92	-69	-65	-60	-69	-85	-82	-89	-86	-82	
13	480.714	22	-96	-92	-89	-90	-98	-96	-98	-84	-83	-86	-85	-87	-85	-85	-85	
14	481.607	22	-96	-94	-94	-95	-96	-96	-98	-85	-83	-89	-86	-89	-86	-87	-89	
15	482.5	22	-96	-98	-93	-94	-94	-98	-93	-82	-83	-86	-87	-87	-86	-86	-88	
16	483.393	22	-99	-93	-91	-90	-97	-94	-94	-83	-83	-86	-86	-92	-87	-87	-90	
17	484.286	22	-97	-91	-93	-94	-95	-98	-88	-82	-82	-81	-84	-85	-84	-86	-83	
18	485.179	22	-97	-94	-93	-92	-97	-95	-82	-71	-75	-77	-84	-84	-90	-87	-85	
19	486.071	23	-90	-82	-91	-84	-84	-90	-85	-83	-79	-79	-81	-83	-76	-84	-78	
20	486.964	23	-78	-81	-75	-77	-81	-79	-84	-75	-79	-82	-85	-82	-79	-82	-80	
21	487.857	23	-75	-76	-76	-74	-76	-74	-80	-74	-75	-76	-78	-78	-78	-77	-80	
22	488.75	23	-76	-73	-67	-73	-69	-75	-76	-76	-75	-75	-76	-75	-80	-76	-78	
23	489.643	23	-70	-65	-69	-65	-68	-67	-71	-70	-74	-76	-76	-72	-73	-74	-74	
24	490.536	23	-66	-64	-64	-73	-73	-68	-68	-65	-72	-74	-72	-66	-73	-70	-78	
25	491.429	23	-69	-72	-70	-66	-68	-71	-68	-66	-65	-66	-72	-66	-68	-71	-75	

Fig. 8: Benin Time Frequency (Urban Area) In Laragon Server Environment

Fig. 9 shows the database structure in laragon server environment and Nigeria TV whitespaces has been chosen as the database name where Ogbona time frequency has been selected and it depicts the frequencies from 470 – 870MHz, their channel I.D and the scan results which were recorded from 12:00am mid night for 24 hours with a total of 448 entries. This corresponds to scan results taken at every 1hour interval.

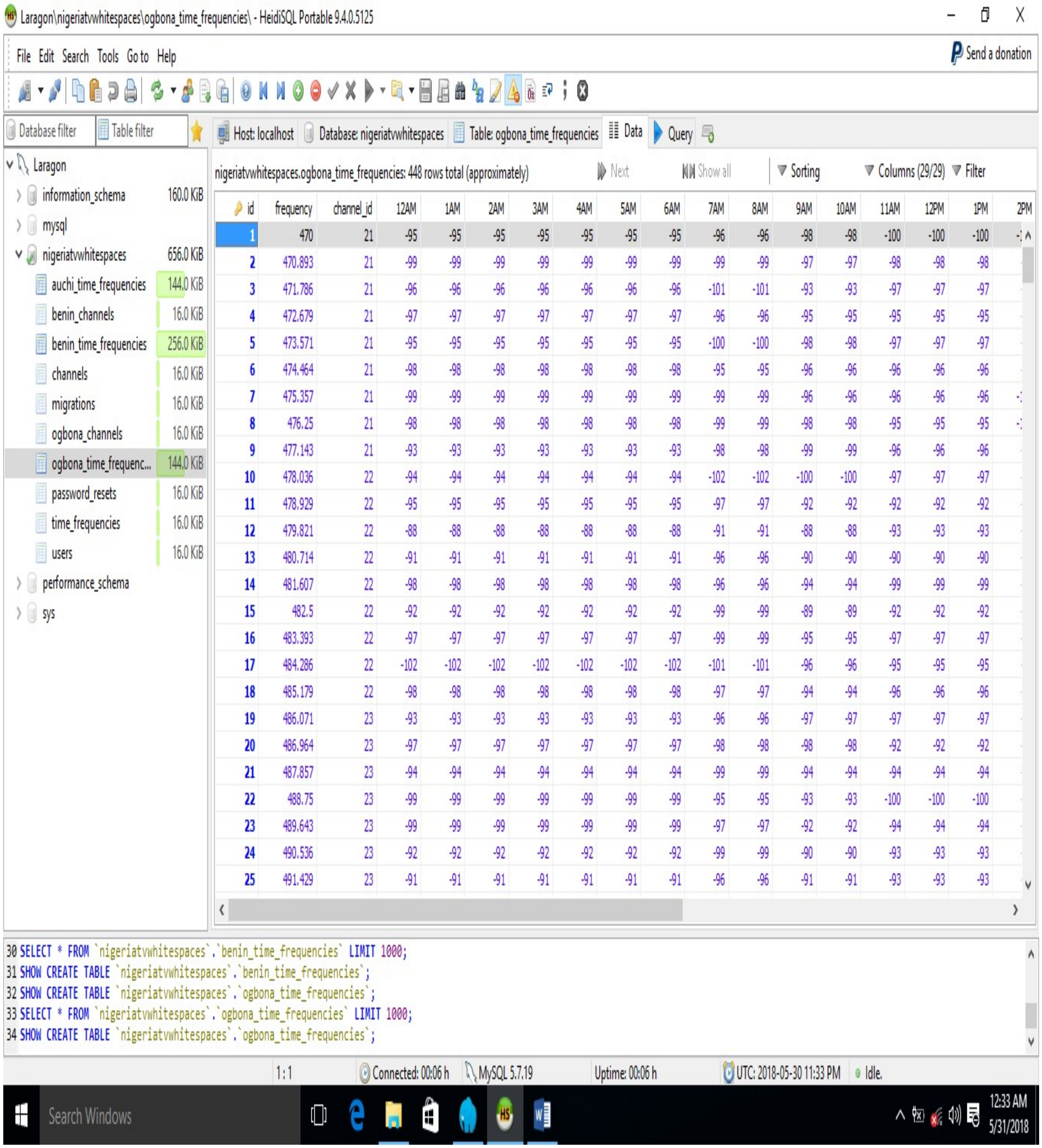

Fig. 9: Ogbona Time Frequency (Rural Area) In Laragon Server Environment

4.2 The Query Page

This is a web page interface for WSDs that was designed using Hyper Text markup language (HTML) and cascaded style sheet (CSS). It collects the necessary information required to query the database from the user (WSDs) which is passed using the server side language (i.e. PHP). This program then receives a request and processes it, returning HTML back to the client. The web server package up a request to the data server through SQL. The data server manages the data and prepares a response to the web server, which then makes HTML output back for the user. Fig. 10 depicts the query page/user interface of the geo-location database as seen by all users that access the database.

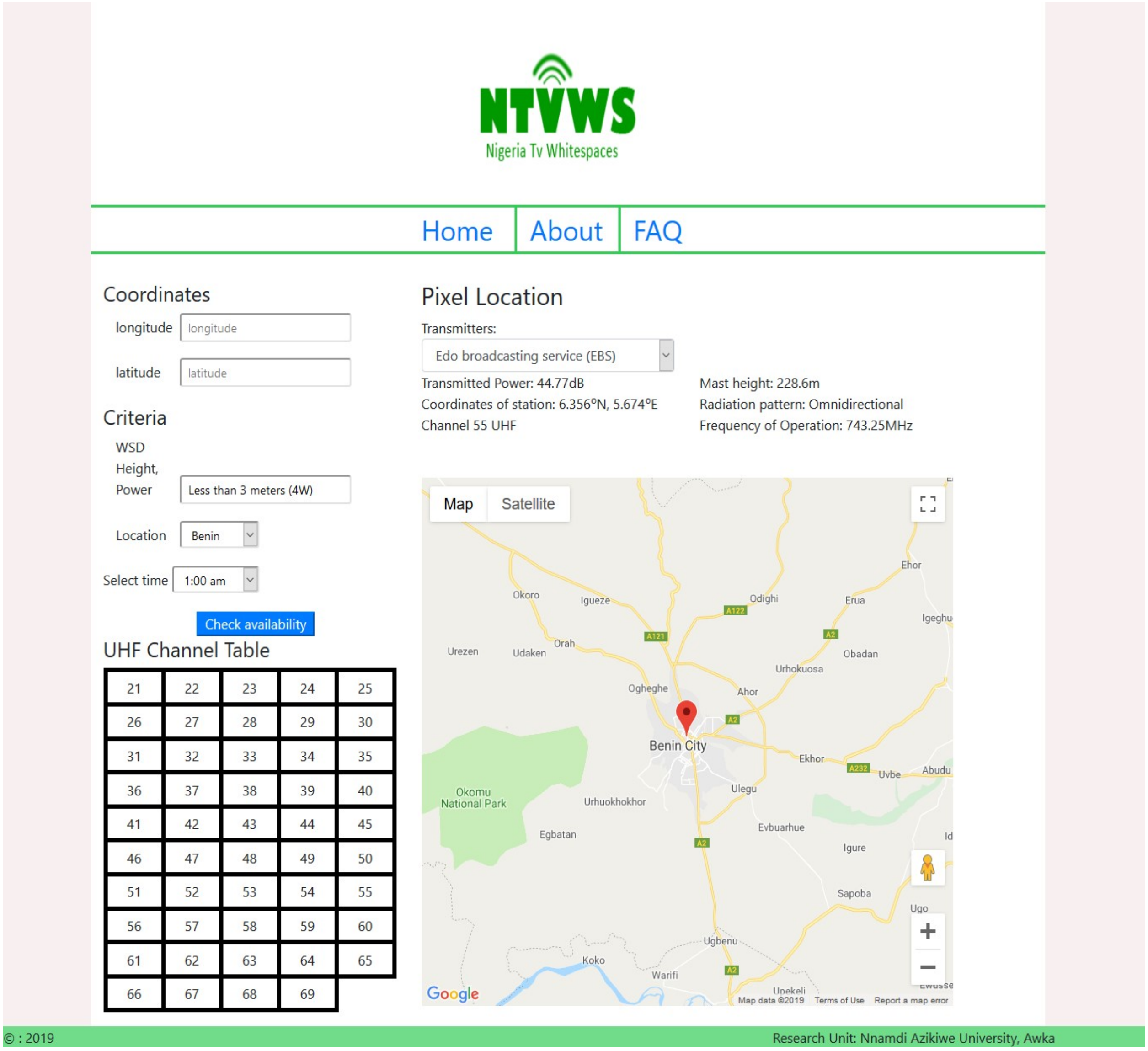

Fig. 10: Query page/User Interface

4.2.1 Query result page

This webpage was designed to analyze and display the results obtained from the back-end of the geo-location database. The query page contain the following specific parameters: name of the transmitter, transmitted power in dB, antenna height, time, location, radiation pattern and frequency of operation which helps in determining whether a channel is occupied or not in a particular location and time. There is also a table of UHF channels at the left hand side of the query page which displays the results of the occupied (white) and unoccupied channels (green), as calculated by the database and also the total available bandwidth for each time and location as selected by the user and it depicts the location concerned, on the Google map using a beacon.

The algorithm that implements the query for TVWS is given below;

- Get the selected time and location from the user
- Pass them as parameters to the controller
- The controller decodes the parameters passed in the request and sends it to the appropriate model
- The model then selects the available channels and sends result as a JSON (JavaScript Object Notation)
- At the frontend the result is looped through and for each of the results the appropriate channel is colored green.

The results are generated and analyzed automatically and finally displayed on the screen. The WSD can now pick a vacant channel over which to transmit.

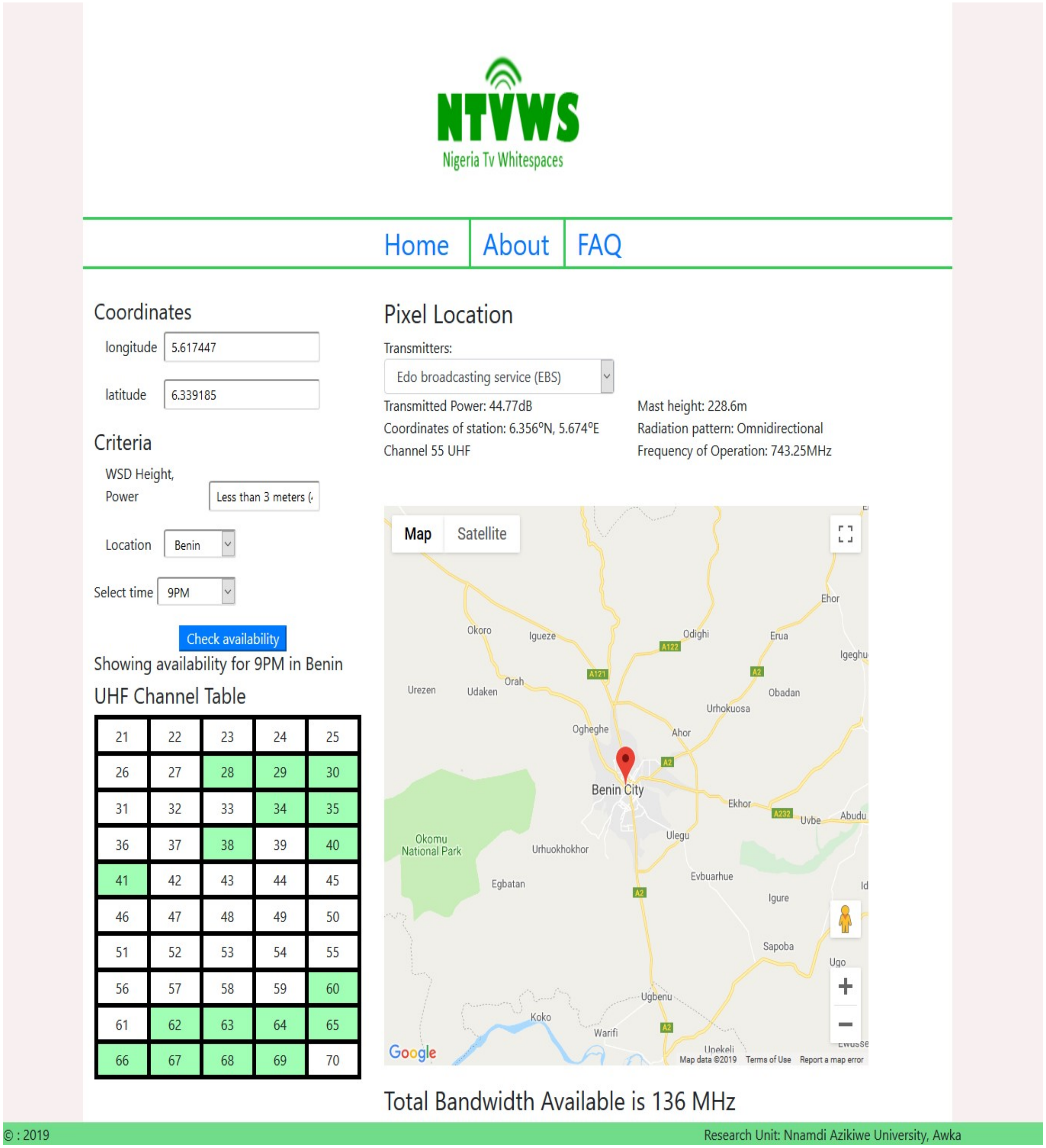

Fig. 11: Benin Query Result Page (Urban Area)

Fig. 11 shows the total number of channels investigated at 9.00pm Nigerian time in Aduwawa axis of Benin City in Edo State. The channel table shows 17 available TVWS channels (green) and 33 unavailable (white) channels in the UHF bands. These were calculated by the geo-location whitespace database and the total bandwidth available is 136MHz for a 4W fixed WSD with an antenna HAAT of between 3metre and 30metre. This shows that in this area and at this specific time selected 66% is occupied while 34% of the channels are free and available to be used by white space device.

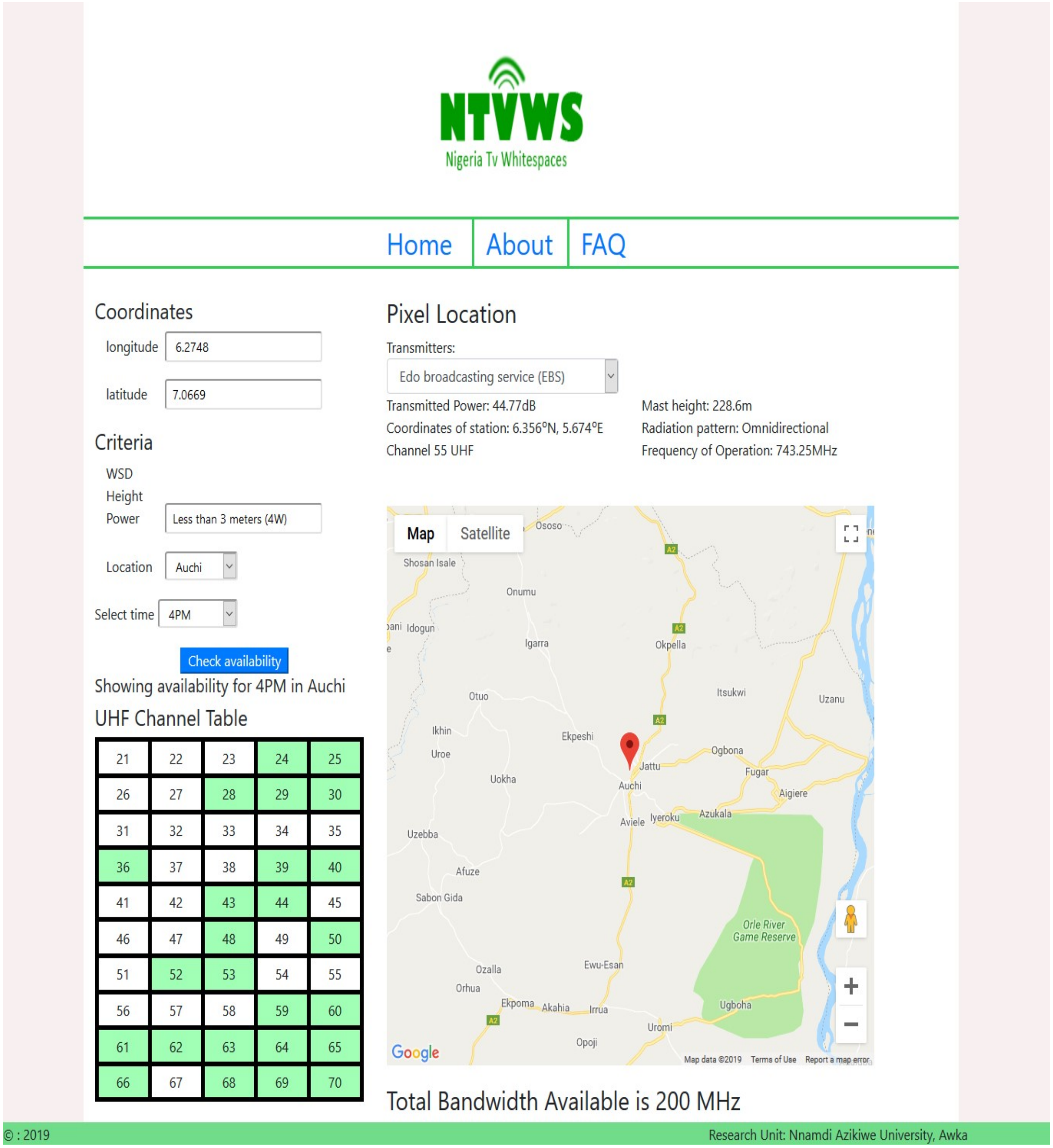

Fig. 12: Auchi Query Result Page (Semi-Urban Area)

Fig. 12 shows the total number of channels investigated at 4.00pm Nigerian time in Auchi which is a semi-urban area in Edo State. The channel table shows 25 available TVWS channel (green) and 25 unavailable (white) channels in the UHF bands. These were calculated by the geo-location whitespace database and the total bandwidth available is 200MHz for a 4W fixed WSD with an antenna HAAT of between 3metre and 30metres. This shows that in this area and at this specific time 50% of the channel is occupied while 50% is free and available to be used by white space device.

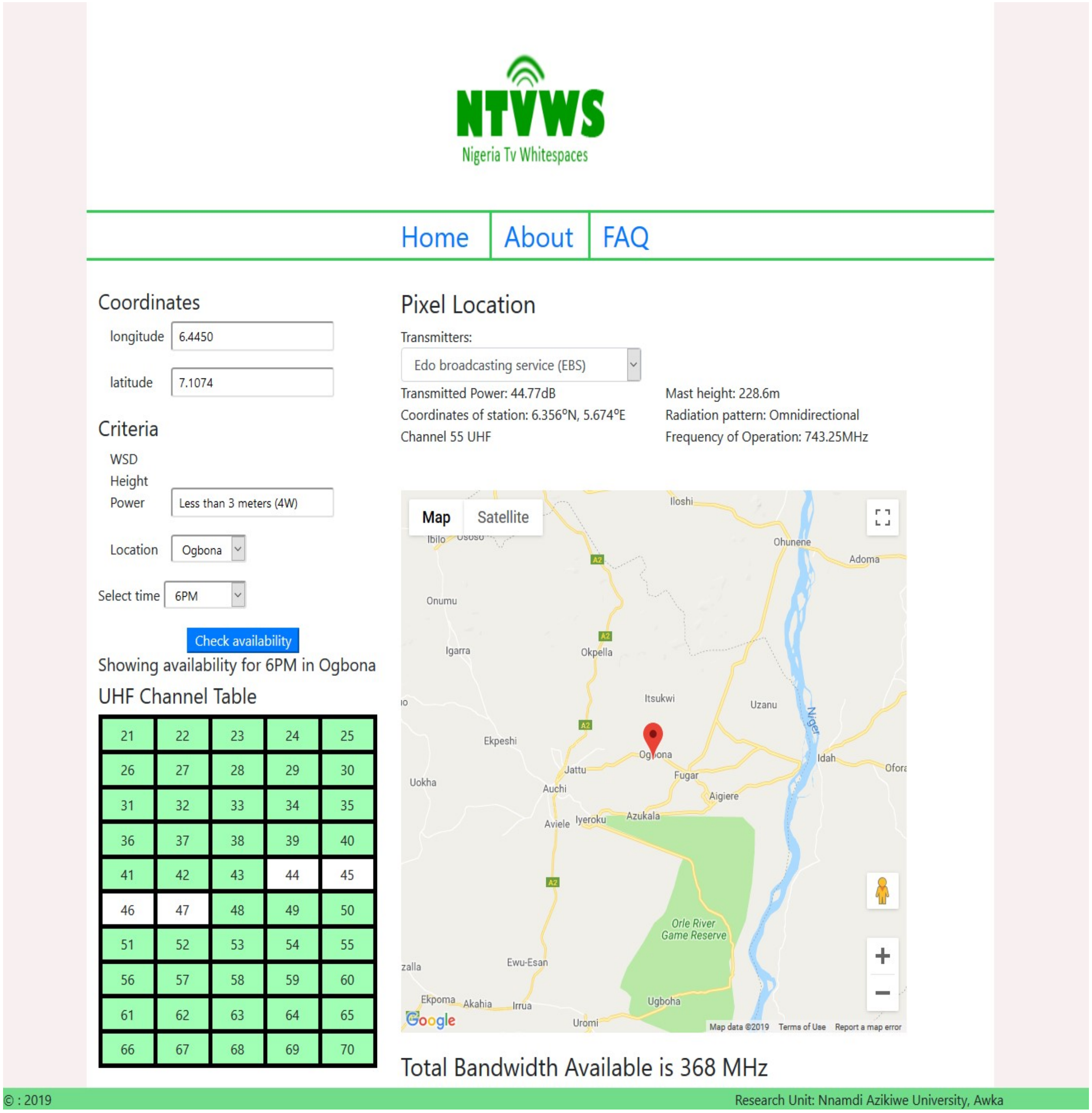

Fig. 13: Ogbona Query Result Page (Rural Area)

Fig. 13 shows the total number of channels investigated at 6.00pm Nigerian time in Ogbona which is a rural area in Edo State. The UHF channel table shows that almost all the channels are free around 6.00pm except for channel 44, 45, 46 and 47 which are occupied. The total bandwidth available which was calculated by the geo-location whitespace database is 368MHz for a 4W fixed WSD with an antenna HAAT of between 3metre and 30metres. This shows that in this area and at this specific time 8% of the channel is occupied while 92% is free and available to be used by white space device.

4.3 Uploading Database and web page to a C-panel

This is the last stage to be carried out in the development of the web based Geo-location database for identifying TVWS. This stage begins only when the database and its associate web pages(s) have been successfully developed and test run on the Laragon or WAMP server after which a C-panel login which is optimized to suit the traffic needs and data capacity requirements of the developed system is secured. Once secured, the web page(s) and database information is uploaded and properly structured.

The domain name used to access the web page(s) is given as follows URL: http://Nigtvwhitespaces.com and the site address is uniquely chosen to direct users (which in this case is the WSDs) to the home page or query page whenever necessary. The WSD then selects from the options made available from the dropdown list, the location and time of the day the user is interested in before the search can commence. The selected options are fed to the backend which is made up of the database (MySQL), server (Apache), PHP 7.0. The database allows the storage of the different frequencies obtained and the bandwidth. The frequencies are being arranged according to their time and a channel I.D is assigned to them.

PHP scripts allows the user interact with the database using the SQL queries being passed on to the database and to obtain results from the database. The framework being used for this design is laravel which is a more object oriented way of writing PHP codes and it ensures a higher form of security by implementing utilities like pretty URLS, CSRF (cross site reference form) etc. The server apache is where the PHP codes are saved and run.

V. CONCLUSION

This research work presents Real Time Received Signal Strength measurements gathered from Urban, Semi-Urban and Rural area of Edo State in Nigeria within the 470-870MHz band and were used to develop a Geo-location database for TVWS which is available online for public access. Results generated by the query page helps identify which channels are occupied by the primary users and which channels are vacant for secondary use. The analysis calculates and displays the amount of unused frequencies at any given location and time of the day selected.

From results analysis generated, it was gathered that only 8% of the frequencies in rural areas is occupied while 92% is free to be used by white space device. Considering each TV channel uses 6MHz of bandwidth and a guard band of 2MHz; the available TV white space of 368MHz which was determined could be reused by cognitive radios.

In summary, this research has shown that there is a great potential for TV white space frequencies to provide broadband internet access in Edo State and especially in rural areas and semi-urban areas where TV white spaces are abundant and internet access is lacking.

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