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RESEARCH ARTICLE

Enabling Wireless Rural Broadband Usage Via TV White Spaces in Delta State University of Science and Technology, Ozoro, Delta State

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ABSTRACT

Broadband high speed internet access has all but become a requirement in today's connected world as it provides a variety of channels of data over a single communication medium. But in rural areas, access to key spectrum is difficult due to financial limitations and unavailability of internet access resources; TV white space (TVWS) which is an emerging technology that utilizes the unused UHF, VHF band on a secondary basics without causing harm or interference on the primary users has a promising potentials of extending broadband internet access to rural environment. Therefore, this research work has examine the UHF TV spectrum occupancy in three selected environs around the Delta State University of Science and Technology, Ozoro, Delta State, using to determine the free and occupied channels. Result shows that within the Ughelli environs for bands within (474-874mhz), a total number of 50 channels are available with 14 occupied representing 28% while 72% are free; and for the Asaba environs, 22 channels of the 50 available channels representing 44% are occupied leaving the other 56% free; and for the Ubulu-ukwu environs,25 of the 50 available channels representing 50% are occupied while others are free.
Keywords: *Wireless Rural Broadband Usage; TV White Spaces; Delta State University of Science and Technology; Internet Access*

Introduction

Recently, wireless industry has undergone significant growth and transformation in recent years, leading to a multitude of innovations and widespread integration of mobile platforms and services into our daily lives. Rapid advancements in wireless communication technologies, such as 4G and 5G, have played a pivotal role in enhancing data speeds, reducing latency, and expanding network capacities. These improvements have paved the way for more sophisticated and efficient mobile services. This rapid growth and development of the wireless communication system can be directly related to the desire of fast data rate and reliable connectivity. Radio frequency spectrum is being utilized by mobile phones, government, security agencies and many other private organizations (Parvez *et al.*, 2018; Dangi *et al.*, 2021). The utilization of wireless system is expected to into increased by 1000 folds by 2050. Improvements in spectrum efficiency and the effective use of available frequency bands would be necessary to accommodate the increased demand for wireless communication (Marsa-Maestre *et al.,* 2019).

Information and communication technologies (ICT) is plays a key role in global socioeconomic growth and industrial development. However, there are some hitches in broadband penetration is some regions of the world. Developed regions have higher coverage guarantees when compared to rural/remote areas. This is attributed to inadequate infrastructural development - unreliable electricity supply and a limited core telecommunication network. The digital divide, characterized by discrepancies in access to and use of information and communication technologies (ICT), remains a global concern (Farhadi *et al.*, 2012). The utilization of TV white spaces (TVWS) as an alternative means for broadband access has attracted a lot of research interest (Zhang *et al.*, 2018; Rahman and Saifullah, 2019). Novelcluster-based broadband system model that does not require operator deployed UHF band nodes. In their

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proposal user premise equipment connects to the users vis WiFi, while the mid-haul connectivity to the BS is carried out over TVWS (Satyam and Swades, 2014; Rahman and Saifullah, 2018).

Ensuring widespread (broadband) quality internet services mostly in the rural regions has become a paramount interest to researchers and developers. Affordable internet access will enhance academic growth and performance (Reddick *et al*., 2020; Sanders and Scanlon, 2021). Quality internet services in rural areas and school environments help to provide students and educators with access to online learning resources, educational content, and remote learning platforms (Olanrewaju *et al*., 2021; Haleem *et al*., 2022). However, related literature review revealed that Delta State University of Science and Technology, Ozoro, Nigeria has no broadband internet service; thus, hindering the learning ability of the students and research/reaching capability of the staff. To achieve the goal of this study, the availability of TV white spaces within Delta State, and proximity to the university community were accessed.

Materials and Methods

Study Area

Delta State University of Science and Technology is located within Ozoro community of Delta State, Nigeria. Ozoro has two major climatic seasons - dry season and rainy "wet" seasons. The dry season is characterized by low rainfall and high temperature and low relative humidity, while the rainy season is mainly characterized by higher rainfall and lower temperature. The mean annual rainfall of the region is about 1800 mm, and the tropical rain forest is the predominant vegetation type found in the community (Akpomrere and Uguru, 2020; Uguru *et al*., 2022).

Experimental Testing

The experimental testing was conducted in three areas: Ughelli, Asaba, and Ubulu-Uku. These locations are in Delta State, Nigeria. The experimental tested for this work is one of the Metro digital mega base stations situated on hills of Ubulu-Uku for digital terrestrial transmission and Quest mega base station situated at Otugor in Ughelli, both stations are in Delta State Nigeria. The base stations are covering over 60 km radius and 100 km respectively with a transmitting power of 600 W and 1000 W. Higher transmitting power generally allows for broader coverage and better penetration through obstacles, contributing to reliable communication services over large areas (Dangi *et al*., 2021).

The study proposed the use of TVWS as the alternative method. The TVWS was evaluated to find out its real existence within the area under consideration. The hardware used to carry out the study was the Anritsu MS2771A Spectrum Analyzer, which was used to measure the magnitude of the input signal versus frequency. Anritsu is known for producing high-quality test and measurement equipment, and the MS2771A is likely designed to provide accurate and precise measurements for detailed signal analysis (Anritsu, 2023). The key functionality of a spectrum analyzer is to display the amplitude of the signal as a function of frequency.

Data Analysis

All the data used for this research was generated from the Metrodigital Communication company and Quest Television and FM station.

Results and Discussion

The results obtained from the field work are presented Tables 1 to 12. The results show that there are numerous TVWS channels underutilized within Delta State; these channels just there can be used for effective access to broadband. In Ughelli, the nearest base station to Ozoro where Delta State University of Science and Technology is located has 37out of 50 channels representing 74% unoccupied and unutilized channels translating to 296MHz. this is a wonderful opportunity for broadband access in the environment. When the spectrum occupancy of 578 to674MHz was analyzed (Table 2), the total number of channels here is 13; Total number of occupied channel was 4 and free channels within this range are 9. This is an indication that 69% of the channels are free to be used by white space devices in that zone.

As revealed in Table 3, based on the frequency of 682 to770MHz in Ughelli area, the findings show that total number of 12 channels was analyzed and total of 5 were occupied while total of 7 was unoccupied. This indicated that 58%

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of the channel can be used by white space devices while 42% are occupied. In Table 4, a total of 12 channels were analyzed and it shows that only 2 channels were occupied and a total of 10 channels representing 83% are unoccupied that can be used for white space devices in that zone. From the analysis made we can deduce that in frequencies 474 to 874MHz we have a total number of fifty (50) channels. The number of occupied channels is 13 representing 26% and unoccupied channels are 37 representing 74%. The analysis from Asaba and environs for frequencies with the range of 474 to 570MHz as shown in Table 6 revealed that there are total of 13 channels. A breakdown of the key findings depicted that the total number of occupied channels were 5; total number of unoccupied (White Space) channels were 8, portraying that this area under study had 38% are occupied while 62% are free spaces to be used by broadband infrastructures in this area.

Table 7 showed that when the spectrum occupancy of 578 to 674MHz was analyzed within Asaba micro-region, the total number of channels here is 13; total number of occupied channel was 4 and free channels within this range are 9. This shows that only 69% of the channels are free to be used by broadband in this area. Similarly, when a frequency of 682 to 770MHz was used in Asaba and environs (Table 8), the findings revealed that total number of 12 channels was analyzed and total of 11 out of the 12 were occupied. This shows that 92% of the channels are occupied; it also shows that white space devices may not be deployed to this frequency range in this area to avoid interference. Hence it can be termed red zone or “no go area zone. Then as another range of frequencies 474 to 866 MHz to analyze 12 channels were used in Asaba metropolis (Table 9), the results show that only 2 channels was occupied and a total of 10 channels representing 83% are unoccupied that can be used for broadband access. From the analysis made we can comfortably say in frequencies 474 to 866 MHz we have a total number of fifty (50) channels. The number of occupied channels is 22 representing 44% and unoccupied channels are 28 representing 56%.

Analyzing 13 channels from another micro region (Ubulu-Uku and environs) with range of frequencies of 474 to 570MHz (Table 10), revealed that 7 channels were occupied channels and total number of unoccupied (white Space) channels were 6. This is an indication that in this area 54% are occupied while only 46% are free for broadband access. This reveals that some of the licensed channels are occupied by their owners. Likewise, when the spectrum occupancy of 578 to 674MHz was analyzed (Table 11) within the same Ubulu-uku region, the results showed that the number of occupied and free channels were 7 and 6, respectively. This revealed that 46% of the channels were free to be used for broadband access in that zone. Lastly, when a frequency range of 682 to 770MHz was applied in Ubulu-Uku area, it shows that total number of 12 channels was analyzed and total of 9 were occupied while a total of 3 was unoccupied. This shows that only 25% of channel can be used by white space devices in this area while 75% are occupied.

This unoccupied spectrum can potentially be utilized by white space devices for various applications, such as broadband access, IoT connectivity, or other wireless communication services (Fantacci and Marabissi, 2016). From the analysis made we can comfortably say in frequencies 474 to 874 MHz we have a total number of Fifty (50) channels. These results are an indication that in major of the area was for broadband access. This reveals that some of the licensed channels are occupied by their owners. The presence of unoccupied spectrum is an opportunity for deploying white space devices to address connectivity needs in the area (Zhang *et al*., 2018).

Table 1: Summary of 474-570MHz Spectrum Occupancy Description in Ughelli and Environs

Frequency Span	**Channel No**	**Status**
474 – 482MHz	21	Occupied/
482 – 490MHz	22	Free
490 – 498MHz	23	Free
498 – 506MHz	24	Occupied/in use
506 – 514MHz	25	Free
514 – 522MHz	26	Free
522 – 530MHz	27	Free
530 – 538MHz	28	Free
538 – 546MHz	29	Free
546 – 554MHz	30	Free
554 – 562MHz	31	Free
562 – 570MHz	32	Occupied/in use
570 – 578MHz	33	Free

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Table 2: Summary of 578 – 682MHz spectrum Occupancy Description in Ughelli and Environs

Frequency Span	Channel No	Status
578 – 586MHz	34	Occupied/
586 – 594MHz	35	Free
594 – 602MHz	36	Free
602 – 610MHz	37	Occupied/in use
610 – 618MHz	38	Free
618 – 626MHz	39	Free
626 – 634MHz	40	Occupied/in use
634 – 642MHz	41	Free
642 – 650MHz	42	Free
650 – 658MHz	43	Occupied/ in use
658 – 666MHz	44	Free
666 – 674MHz	45	Free
674 – 682MHz	46	Occupied/in use

Table 3: Summary of 682 -770MHz Spectrum Occupancy description in Ughelli and environs.

Frequency Span	Channel No	Status
682 – 690MHz	47	Occupied/
690 – 698MHz	48	Occupied/in use
698 – 706MHz	49	Occupied/in use
706 – 714MHz	50	Occupied/in use
714 – 722MHz	51	Free
722 – 730MHz	52	Reserved
730 – 738MHz	53	Reserved
738 – 748MHz	54	Free
748 – 754MHz	55	Free
754 – 762MHz	56	Free
762 – 770MHz	57	Free
770 – 778MHz	58	Free

Table 4: Summary of 778 – 874MHz Description in Ughelli and Environs

Frequency Span	Channel No	Status
778 – 786MHz	59	Reserved
786 – 794MHz	60	Reserved
794 – 802MHz	61	Free
802 – 810MHz	62	Free
810 – 818MHz	63	Free
818 – 826MHz	64	Free
826 – 834MHz	65	Free
834 – 842MHz	66	Free
842 – 754MHz	67	Free
754 – 762MHz	68	Free
762 – 770MHz	69	Free
866 – 874MHz	70	Free

Table 5: Summary of 474 – 570MHz Spectrum Occupancy Description in Asaba and Environs

Frequency Span	**Channel No**	**Status**
474 – 482MHz	21	Occupied/in use
482 – 490MHz	22	Occupied/in use
490 – 498MHz	23	Occupied/in use
498 – 506MHz	24	Occupied/in use
506 – 514MHz	25	Free
514 – 522MHz	26	Free
522 – 530MHz	27	Free
530 – 538MHz	28	Free
538 – 546MHz	29	Free
546 – 554MHz	30	Free
554 – 562MHz	31	Free
562 – 570MHz	32	Occupied/in use
570 – 578MHz	33	Free

Table 6: Summary of 578 – 666MHz Spectrum Occupancy description in Asaba and Environs

Frequency Span	**Channel No**	**Status**
578 – 586MHz	34	Free
586 – 594MHz	35	Free
594 – 602MHz	36	Free
602 – 610MHz	37	Occupied/in use
610 – 618MHz	38	Free
618 – 626MHz	39	Occupied/in use
626 – 634MHz	40	Free
634 – 642MHz	41	Free
642 – 650MHz	42	Free
650 – 658MHz	43	Free
658 – 666MHz	44	Free
666 – 674MHz	45	Occupied/in use
674 – 682MHz	46	Occupied/in use

Table 7: Summary of 682 – 770MHz Spectrum Occupancy Description in Asaba and Environs

Frequency Span	Channel No	Status
682 – 690MHz	47	Occupied/
690 – 698MHz	48	Occupied/in use
698 – 706MHz	49	Occupied/in use
706 – 714MHz	50	Free
714 – 722MHz	51	Occupied/in use
722 – 730MHz	52	Reserved
730 – 738MHz	53	Reserved
738 – 748MHz	54	Occupied/in use
748 – 754MHz	55	Occupied/in use
754 – 762MHz	56	Occupied/in use
762 – 770MHz	57	Occupied/in use
770 – 778MHz	58	Occupied/in use

Table 8: Summary of 778 – 866MHz Spectrum Occupancy Description in Asaba and Environs

Frequency Span	**Channel No**	**Status**
778 – 786MHz	59	Reserved
786 – 794MHz	60	Reserved
794 – 802MHz	61	Free
802 – 810MHz	62	Free
810 – 818MHz	63	Free
818 – 826MHz	64	Free
826 – 834MHz	65	Free
834 – 842MHz	66	Free
842 – 754MHz	67	Free
754 – 762MHz	68	Free
762 – 770MHz	69	Free
866 – 874MHz	70	Free

Table 9: Summary of 474-570MHz spectrum Occupancy Description in Ubulu-Uku and environs

Frequency Span	Channel No	Status
474 – 482MHz	21	Occupied/in use
482 – 490MHz	22	Occupied/in use
490 – 498MHz	23	Occupied/in use
498 – 506MHz	24	Occupied/in use
506 – 514MHz	25	Free
514 – 522MHz	26	Free
522 – 530MHz	27	Free
530 – 538MHz	28	Free
538 – 546MHz	29	Free
546 – 554MHz	30	Free
554 – 562MHz	31	Occupied/in use
562 – 570MHz	32	Occupied/in use
570 – 578MHz	33	Occupied/in use

Table 10: Summary of 578 – 674MHz Spectrum Occupancy Description in Ubulu-Uku and environs

Frequency Span	Channel No	Status
578 – 586MHz	34	Free
586 – 594MHz	35	Occupied/in use
594 – 602MHz	36	Free
602 – 610MHz	37	Occupied/in use
610 – 618MHz	38	Free
618 – 626MHz	39	Occupied/in use
626 – 634MHz	40	Free
634 – 642MHz	41	Free
642 – 650MHz	42	Occupied/in use
650 – 658MHz	43	free
658 – 666MHz	44	Occupied/in use
666 – 674MHz	45	Occupied/in use
674 – 682MHz	46	Occupied/in use

Vol. 7, No. 3 | 2023 | 32-39| DOI: https://doi.org/10.5281/zenodo.11120479
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Table 11: Summary of 682 – 770MHz Spectrum Occupancy Description in Ubulu-Uku and environs

Frequency Span	Channel No	Status
682 – 690MHz	47	Occupied/in use
690 – 698MHz	48	Occupied/in use
698 – 706MHz	49	Occupied/in use
706 – 714MHz	50	Free
714 – 722MHz	51	Occupied/in use
722 – 730MHz	52	Occupied/in use
730 – 738MHz	53	Reserved
738 – 748MHz	54	Free
748 – 754MHz	55	Occupied/in use
754 – 762MHz	56	Free
762 – 770MHz	57	Occupied/in use
770 – 778MHz	58	Occupied/in use

Table 12: Summary of 778 -866MHz Spectrum Occupancy Description in Ubulu-Uku and Environs

Frequency Span	Channel No	Status
778 – 786MHz	59	Reserved
786 – 794MHz	60	Reserved
794 – 802MHz	61	Free
802 – 810MHz	62	Free
810 – 818MHz	63	Free
818 – 826MHz	64	Free
826 – 834MHz	65	Free
834 – 842MHz	66	Free
842 – 754MHz	67	Free
754 – 762MHz	68	Free
762 – 770MHz	69	Free
866 – 874MHz	70	Free

Conclusion

Advancements in technology are rapidly transforming how we work, communicate, access information, and educate our children. However, many tertiary institutions in Nigeria are reported to lack a critical connection to broadband internet. This can limit their ability to fully leverage technological advancements, impacting various aspects of education, communication, and access to information. Their lack of broadband access means educational opportunities enjoyed by developed surveyed that will bring when implemented greater access to broadband for the benefit of students and staffs in the environment. This study shows that there is greater percentage of available TVWS that are underutilized that can be converted into use for high penetration of broadband access.

Considering the findings from this work, the following points were recommended:

i. The former base station of Nitel located at the central point of Ozoro town should be utilized since it has been laying fallow since the phasing out of Nitel in Nigeria. Repeater should be installed on that gigantic tower to boast the signals around the environs,
ii. The Federal government of Nigeria to expedite the Digital Switch Over (DSO) process is aligned with a strategic approach to address the broadband access challenges in tertiary institutions, and
iii. Proper implementation algorithm should be created that will monitor the interference of wireless devices in relation to the incumbent users.

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