Using TV white space spectrum as Wi-Fi to connect to the unconnected in the developing countries; the methodology.

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ACRONYMS

BS - Base Station

CPEs- Customer Premise Equipment's

EIRP - Effective Isotropically Radiated Power

ICT - Information and Communication Technology

IEEE - Institute of Electrical and Electronics Engineers

IMT - International mobile telecommunications

IP – Internet Protocol

PMP - Point to Multi-Point

SDGs - Sustainable Development Goals

TVBD - Television Broadband Devices

TVW - Television white space

UHF - Ultra High Frequency

VHF - Very High Frequency

WSDs - White Space Devices

Abstract

Wireless technology with converged voice and data applications can provide rural internet spectrum connectivity to allow proper information and communication technology (ICT) boosting across all areas of human life. White spaces' in UHF bands traditionally used for television broadcasting but the opening of TV white space (TVWS) bands for cognitive access is one of the first tangible steps to solve the problem of spectrum scarcity in existing wireless networks. This paper focuses on brief the TV White Space technology, the TVWS architecture, the use of TVWS, the related TVWS process requirements, the Trials, the advantages of this technology and concludes by supporting and advocating for the use of this wireless technology to connect the unconnected.

Introduction

Globally, approximately four billion people still need to embrace the internet. The global community is committed to expanding connectivity and encouraging adoption by including internet access in the Sustainable Development Goals (SDGs) [1]. Mobile and internet services have the power to transform lives, offering financial, medical, and many other life-enhancing resources, as well as the simple ability to express yourself to your family and community. But millions of people in emerging markets do not have access to these services, and even those who have access often do not implement services because of restricted availability, perceived value, and the desire to use the services [2]. The resulting gaps in access and adoption threaten to exacerbate existing economic and social inequities faced by low-income rural communities in emerging markets, especially among the poor in the developing world.

Spectrum sharing offers new ways to cross the online divides between urban and rural areas and between the connected and the unconnected with the latest technological advances. But what is the distribution of spectrum? How can new technological advances make this a useful tool for rural connectivity? Were policymakers willing to embrace this new solution?

This paper answers the above questions and provides some insights into what needs to happen in order to enable spectrum sharing to better maximize spectrum use, boost internet accessibility, and achieve the wider objectives of digital inclusion of governments and a digital economy open to all.

Background Information

There are now more than 3.5 billion mobile internet users around the world and fast-growing mobile data traffic. There is also a rapid increase in traffic on Wi-Fi networks. By 2022, wired networks will account for just 29% of IP traffic, while Wi-Fi and mobile networks will make up for 71% of IP traffic, up from 52% in 2017. Nearly 549 million public Wi-Fi hot spots will be available worldwide by 2022, up from 124 million hot spots in 2017, [3].

Although internet usage continues to grow at remarkable levels, it is important to recognize that growth is not evenly distributed – the rural-urban divide still exists in many countries and relatively large segments of the population remain unconnected.

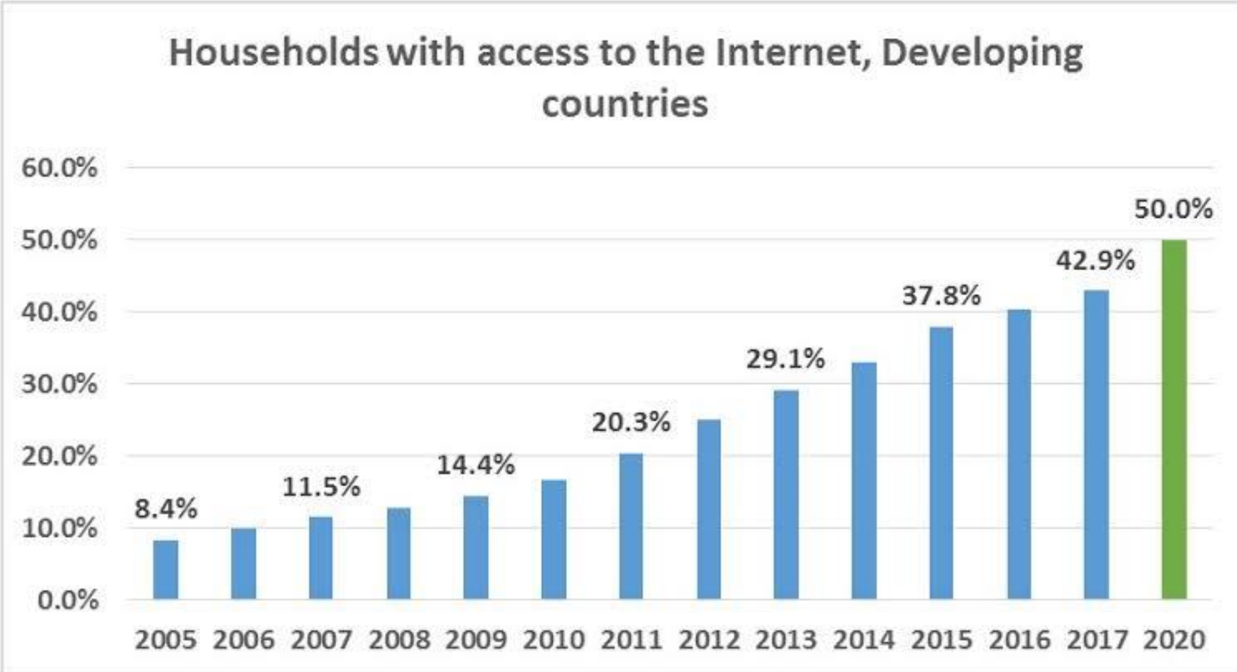

Figure 1 Internet Access growth in developing countries

Source: ITU 2019

The continued digital divide between urban and rural areas presents policymakers with multiple challenges. On the one hand, they have to work on how best to use their limited spectrum resources to enable new technologies, such as 5 G, Wi-Fi 6, and the industrial Internet of Things, which will continue to drive even higher levels of data traffic. At the same time, concerted steps must be taken to bridge the digital divide, promote the SDGs and fulfill the promise for all people of a prosperous digital economy [3].

A change in orientation is what is required. Policymakers should understand what scientists are already realizing and businesses are already implementing: the future of spectrum is about different forms of sharing. Exclusive privileges in certain cases are still desirable, even necessary. Both must, however, operate within a broader sharing matrix to optimize the power available. Such a policy approach encourages the majority of users and apps to take advantage of airwaves rather than just picking winners. At the same time, as a mechanism for innovation and free expression, it will extend the long tradition of wireless communication [4].

The Spectrum

Wireless frequencies used primarily for communication are referred to as spectrum [4]. For more than a century, wireless communications technologies have been commercially viable, beginning with radio broadcasting and television, satellite communications, cellular telephony and many other applications. Today, these sectors reach nearly every American and produce a great deal of economic activity. Spectrum varies from other basic inputs for economic growth and innovation in important ways, however [5] .

Technological advances have facilitated more effective spectrum sharing and communication upgrading. Sharing spectrum can potentially help policymakers ensure that in the digital age no person is left behind, and that access to broadband and the internet is not a privilege, but a basic service open to everyone [3].

Research by Dynamic Spectrum Alliance shows that "Through the ITU, a number of spectrum bands in the 700MHz to 3GHz range have been identified to support international mobile telecommunications (IMT). These include the 700MHz, 900MHz, AWS, 1800MHz, 2100MHz, 2.3GHz, 2.6GHz and 3.5GHz bands" [3].

Spectrum bands below 3GHz have good propagation features, helping to reduce the cost of providing extensive coverage, allowing end-users to benefit from low service prices. This IMT spectrum, however, is not being fully exploited in many countries, which is commonly used by mobile network operators to provide cellular connectivity [3].

TV White Space

In the old analog TV broadcast bands known as VHF (Very High Frequency) and UHF (Ultra High Frequency), TV WhiteSpace, TVWS or simply WhiteSpace is the name for unused wireless frequencies. The conversion to digital television broadcast has opened up large quantities of extremely valuable data communications spectrum. WhiteSpace's special characteristics as a public-domain communications medium are similar to traditional Wi-Fi, but have a connection range measured in hundreds or even thousands of meters, not in 10 meters [6].

When technology progresses, several wired and wireless technology solutions are available to provide broadband connectivity. Providing wired connectivity in sparsely populated rural areas, as discussed in the previous section, is a costly solution. Wireless standards such as IEEE 802.11

(commonly known as Wi-Fi), IEEE 802.11ad and WiGig etc. may be appropriate [7]. Nonetheless, these solutions will only be able to connect limited areas due to the difficult especially in developing countries and the need for high towers. A change from conventional technology to a more accessible, effective and reliable technology is required in order to provide omnipresent connectivity in such areas [7].

Such a scenario is exactly suited to wireless solutions based on TV White Space. There is a significant amount of spectrum available and underutilized in this band in developing countries. Besides this, it also has several unique advantages such as characteristics of non-line sight propagation and ease of deployment.

The 470–806 MHz sub-band in the Ultra High Frequency (−UHF) channel (i.e. Channel 21–62) is mainly reserved worldwide for terrestrial television broadcasting. Co-channel TV broadcasting stations and therefore their coverage areas are geographically separated to avoid radio interference in traditional radio system planning. As a result, some TV channels are not being used at all times at certain locations. These television channels are generally referred to as a scarce resource, i.e. TVWS or TVWS spectrum sample [8].

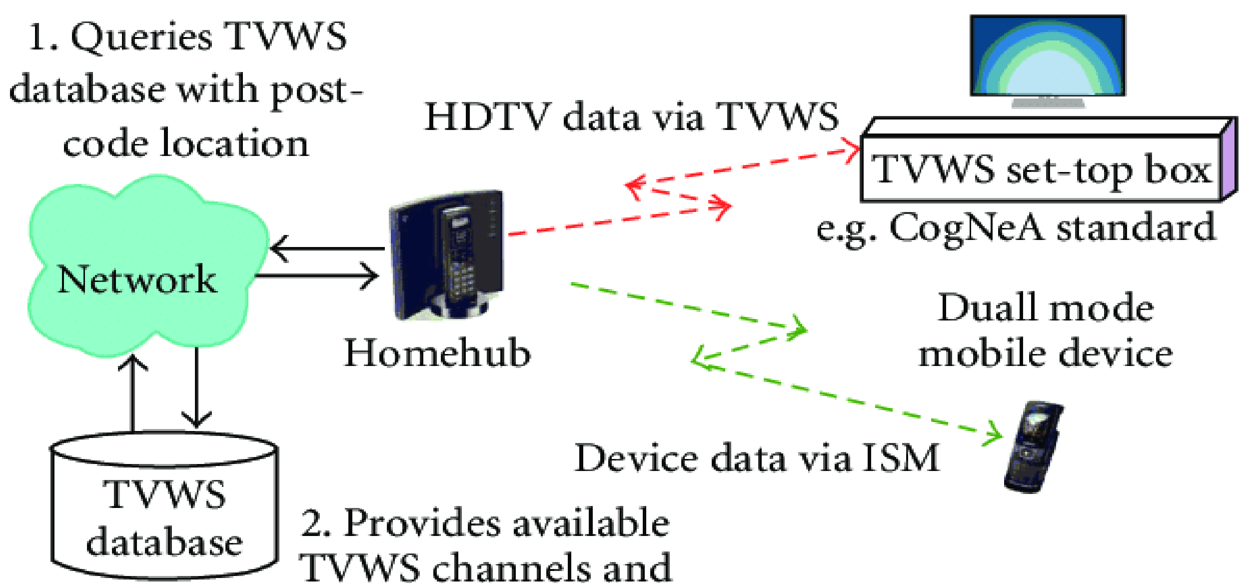

Figure 2 TVWS Concept

Source: Research gate (2019)

TV white space rules by which unlicensed devices, called TV Broadband Devices (TVBDs), can make use of specific TV channels in the Very High Frequency (VHF), and Ultra High Frequency (UHF) bands. But in order to know that frequencies and power levels are safe to use at a given location, white space devices (WSDs) either need to track the radio spectrum to see which channels are available, or they need to know their location so that they can ask a regional database to tell them what is permitted [9].

Basic Mechanism of TVWS

Basic Mechanism of TVWS are given below [8].

i. Devices only use the TV White Spaces channels specified by the database.
ii. Devices are required to re-check the database for the list of available channels
iii. Databases are prohibited from providing devices access to the channels occupied by incumbent operators. Such as broadcasters.
iv. Databases are required to maintain up to date lists of protected operators.
v. Databases can block newly occupied channels to prevent further white spaces access. In Figure 3 shows basic mechanism of TVWS

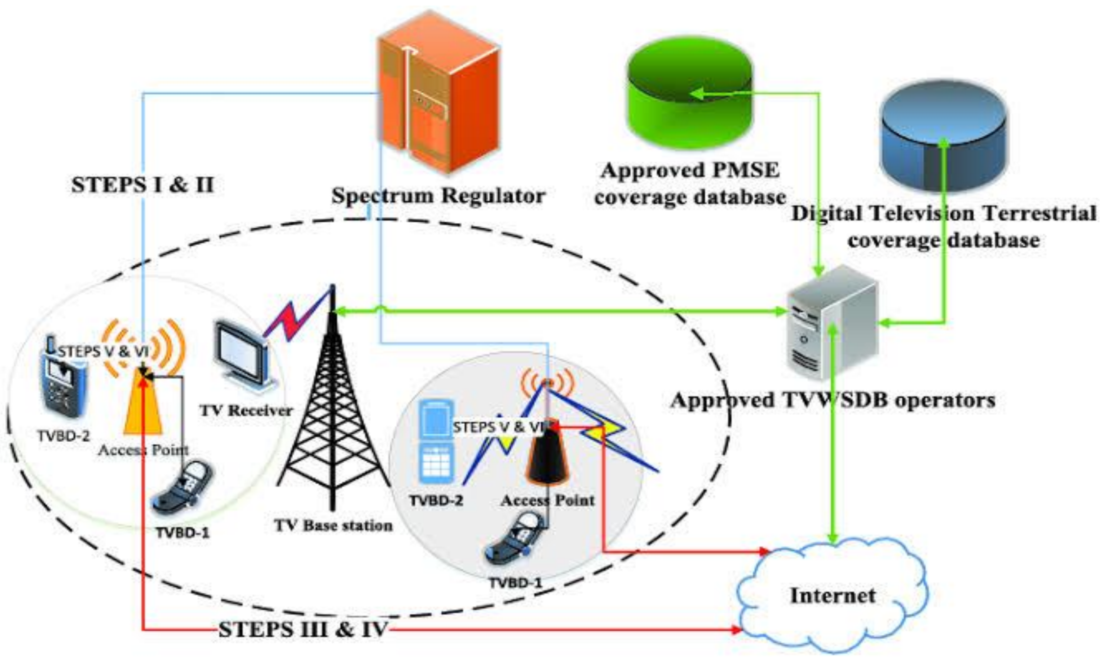

Figure 3 Basic Mechanism for TVWS Architecture

Source: ResearchGate (2019)

TV White Spaces Trials

In the UHF bands, which have been widely used for television broadcasting, there has been increasing interest in telecommunications use of relatively white spaces. This interest is fuelled in more and more countries by the now inexorable move toward digital terrestrial television broadcasting, the consequential and imminent end of analog terrestrial television broadcasting, continued growth in internet usage and increased demand for wireless broadband access. The United States already has a range of qualified server managers and is the front leader in TVWS-based network deployment. In the deployment process, the UK and Singapore are also hurrying [8]. UK has had a range of pilot trials related to Smart City, Rural Broadband, Wi-Fi Hotspot, M2M connectivity, sensor networks, and so on. Singapore has deployed a range of TVWS-based smart grid technologies and undertakes a variety of pilot trials for a number of use case scenarios [8].

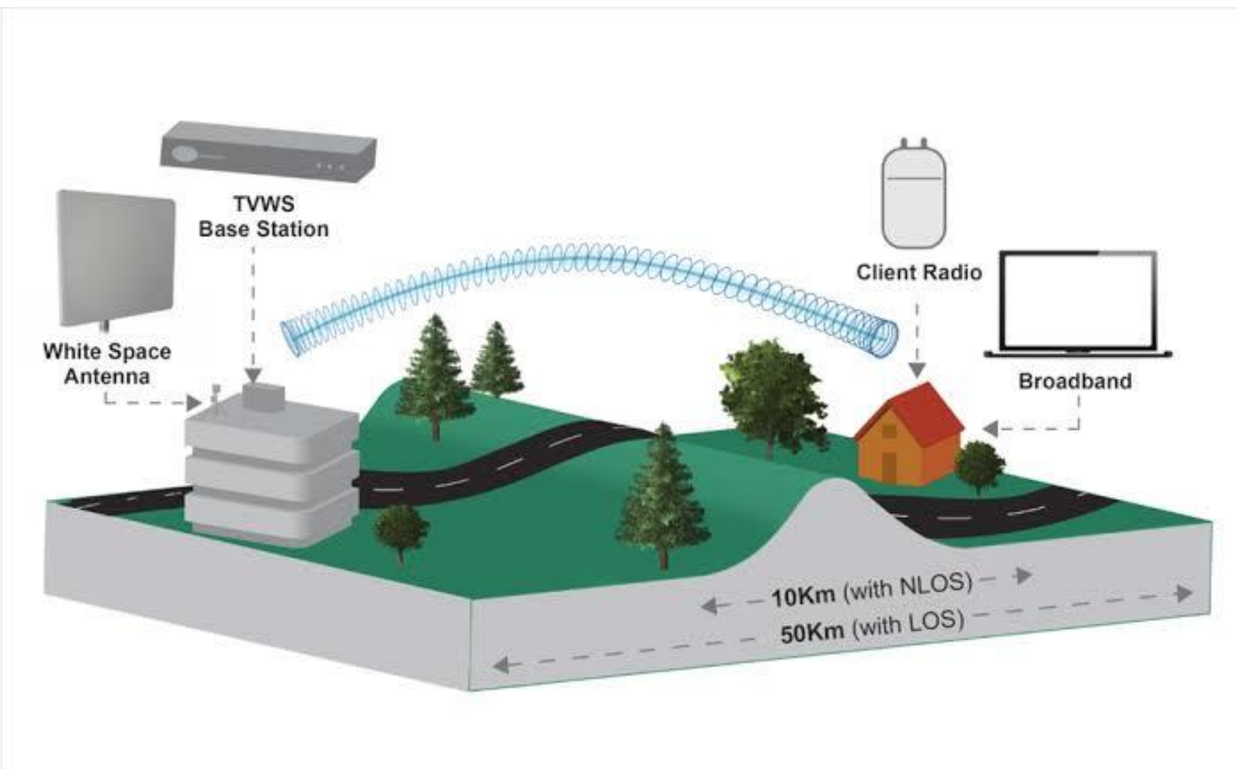

Figure 4 Showing a pictorial trial of TVWS in UK

Source: Microsoft (2018)

TV White Space Standards

Many TV White Space standards such as IEEE 802.22, IEEE 802.11af, IEEE 802.19.1, IEEE 802.15.4 m, IEEE 1900.7 and ECMA 392 have been established. Of all these standards, IEEE 802.22 and IEEE 802.11af are the two most relevant standards for providing rural connectivity. IEEE 802.19.1 is relevant to the coexistence of IEEE 802 in the White Space TV family [7].

IEEE 802.22:

IEEE 802.22 was the first cognitive-based specification established for white space TV access. Wireless broadband access in rural and remote areas is the most important application of this standard. The standard specifies that only 4 W of Effective Isotropically Radiated Power (EIRP) can achieve a wide range of 33 km. To access the TV White Spaces, the standard uses both geo-location database and sensing-based techniques.

IEEE 802.22 follows a Point to Multi-Point (PMP) topology with a Base Station (BS) and its associated Customer Premise Equipment's (CPEs). To protect the incumbents, it follows a strict master-slave relation where BS is a master and the CPEs are its slaves. No CPE can transmit before receiving an authorization from the BS [7].

IEEE 802.11af:

IEEE802.11af specification or White-Fi for the modification of current IEEE 802.11 for TV band operation was developed. IEEE 802.11af systems operate at frequencies below 1 GHz and use the TV band's geo-location database. Due to congestion in the unlicensed band, i.e. 2,4 GHz and 5 GHz spectrum, this standard was designed. There are two IEEE 802.11af operating scenarios. Outdoor and indoor. The indoor scenario has a Wi-Fi-like range of up to 100 m. The outdoor scenario has a distance of about a few kilometers and is more suitable for rural environments [7]. As TV channels may have varying bandwidths of 6, 7 or 8 MHz, it is required to aggregate the bandwidth. This standard works with the bandwidth of 5, 10, 20 and 40 MHz and hence depending on the availability of the channel, this bandwidth can be adapted.

Benefits of TV white Spaces

The key advantages for TVWS of long range and high penetration are the following:

Low cost of capital expenditure (CAPEX): A smaller number of devices are needed to connect an area with a longer range and better penetration.

Low cost of operating expenditure (OPEX): With the license-exempt nature of TVWS as well as smaller facilities (site access, rental, etc.), the cost of owning and operating a network is significantly lower than alternatives.

Easier and quick set up: It is very easy and fast to deploy TVWS. This also means lower deployment costs in addition to non-tangible savings, such as minimal disruption to individuals and businesses, faster replacement of existing technologies, etc.

Good performance: Rain fog and other natural phenomena impact TVWS less. TVWS network is therefore much more robust than networks that use higher frequencies like 2.4 GHz and 5.8 GHz.

Low latencies: because of the larger bandwidth available, latencies are significantly reduced, especially for large networks. The latencies can be decreased by up to 100 times compared with narrow-band IoT networks that run at 900 MHz frequencies.

Improved security: Networks with a larger bandwidth and therefore a smaller capacity is more vulnerable to security threats, e.g. if DDoS attacks occur, smaller capacity networks can be quickly downgraded.

Conclusion

The availability of TV White Spaces is a great opportunity for broadband communications to have better coverage and substantial bandwidth. In this paper, a wireless broadband network based on TV White Spaces together with a sustainable economic model is suggested that not only offers connectivity but also enables the network to function efficiently in rural areas. WhiteSpace is also special for its non-line-of-sight and penetrative capabilities allowing signals to pass through obstructions like trees and buildings and even over small hills. WhiteSpace is open shared spectrum but requires no fees, permits or even towers to establish direct data links between locations kilometers apart. As the role of digital technologies in everyday life continues to grow, most developing countries are rightly aiming to bring broadband connectivity to their entire populations. But licensing IMT spectrum to individual mobile operators may not be enough to deliver this goal – in some cases, the mobile operator's business model doesn't make it financially viable to serve remote rural communities. Developing Countries would better pursue the concept of TVWS to connect to their unconnected so as to bridge the digital divide among their netizens.

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