TVWS Base Band radio module

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Abstract- The recent trend of wireless communication is directly linked with the fast data rate and reliable connectivity. Radio frequency spectrum is one of the emerging technology which is being utilized by mobile phones, government, security agencies and many other private organizations. Licensed but unutilized television (TV) band spectrum is called as TV white space. Now a days very good wireless radio propagation characteristics is Ultra high frequency (UHF) TV band spectrum.Over 90% of the sub-gigahertz spectrum is under utilized in India. TV White Space is the master-stroke needed for Digital India White Space for connecting Last-Mile Rural Broadband. This paper mainly focuses the Development of TVWS and Rural Broadband for TVWS.

Keywords – Digital India, White Space, Rural Broadband

I. Introduction

Digital India is an initiative Project of Government of India to integrate the government departments and the people of India.The main ambition of this Project is to ensuring that the government services are made available to citizens electronically by reducing paperwork. To provide internet facility to every citizens of india mainly reach internet connection to the rural area. Digital India has three core components. These include:

- Digital infrastructure creation
- Digitally providing Services.

Government of India projected at Rs 1,13,000 crores for Digital India. This will be help to preparing the India for delivering good governance to citizens by synchronized and the knowledge based transformation and co-ordinated engagement with both Central Government and State Government[1].

With increasing demand for bandwidth, several researchers schoolars around the world have studied and measured the occupancy of spectrum in different countries. The overall usage of the analyzed spectrum is as low as 4.54% in Singapore, 6.2% in Auckland, 17.4% in Chicago and 22.57% in Barcelona. Among all the unutilized portions of the frequency spectrum, white spaces in the Ultra High Frequency (UHF) Television (TV) bands have been of particular interest owing to the superior propagation characteristics as compared to the higher frequency bands.

White Space:

White Space is a part of the spectrum, which is mainly available for radio communication applications (services and systems) in a given geographical area at a given time on a non-interfering with regard to other services with a higher priority on a national basis.

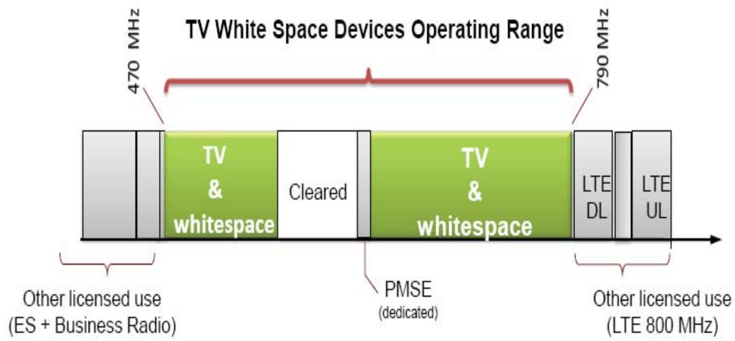


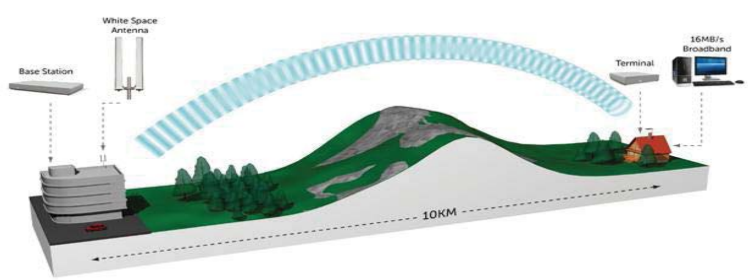
Fig Shows 1.1TV White Space Band

White space, in a communications context, refers to underutilized portions of the radio frequency (RF) spectrum. Large portions of the Spectrum are currently unused, in particular the frequencies allocated for analog television and those used as buffers to prevent interference between channels.

TVWS:

Unused spectrum in the television band (so-called TV white space) has the potential to provide new spectrum for provide information and communication services in developing countries. The growing demand for wireless data transmission drives the search for alternatives to the current spectrum management schemes. In the long term, the only viable solution seems to be dynamic spectrum access once the technical details for its implementation are solved.

TV White Space Communications is the most preferred wireless alternative for long distance communication. A single base station can reach households that are as far away as 10km – 30km depending on antenna height. Since it uses UHF spectrum, signal penetrates easily through vegetation, rains and terrains providing good quality of service (and improve customer retention)[2].



Compared to Wifi and Cellular, TV Whitespace is ideally suited for communication in rural areas for the following reasons.

- Lower capex to setup infrastructure (one base station per 300 sq km area)
- The network can be installed and configured in as little as few hours
- Delivers data at broadband speed (>2 Mbps)
- Lower operational costs (easy to maintain)

II. LITERATURE SURVEY

The radio propagation range of TV white-space is very large compared to Wi-Fi due to its frequency. Their research model shows that the radio propagation losses are much less compared to 2.4 and 5 GHz range. These characteristics help TV white space technology cover large geographic distances without considerable fading, which is ideal for providing broadband services in developing countries and its rural areas. These properties of TV white space result in a low infrastructure cost. Lower infrastructure cost and higher coverage will balance the low financial returns in rural areas of developing countries and attract vendors to provide services in rural areas also bridging the digital divide. A few methods have been proposed regarding usage of TVWS for the secondary users. Methods such as geolocation database and spectrum sensing have been proposed to prevent interference to the primary users of the TV spectrum from the secondary users. A spectrum sensing technique identifies the available spectrum holes, and detects the transmission by primary users of TVWS. The geolocation database requires primary users to be registered in the database. The secondary users first have to identify their locations, and can get information about available free channel and maximum transmit power from the appropriate database. The digital switchover (DSO) in India has not been completed yet because of the high penetration of analog television in the rural areas, and it will take around 3 more years. Few studies have been conducted regarding policy modifications to support TVWS in India. The sub band of 1GHz that has been assigned for TV broadcasting is not being utilized efficiently at given amount of time and location and, therefore, researchers believe that underutilized channels can be used to provide Internet access through TVWS technology. Mayank Kumar at Yantra Electronics Systems Pvt. Ltd. studied the TV band spectrum allocation in India (National Frequency allocation Plan, 2008), which reveals that a large band of frequencies (470 MHz – 698 MHz) are allocated for TV transmission. But, in India there are very few terrestrial TV broadcasting stations which only include the state run Doordarshan (DD1), DD Metro, DD News and other regional channels, as opposed to Europe and US where all available TV bands have been used. Thus, large chunks of unused spectrum are available in this band which could be opened up for licensed or un-licensed use to drive broadband penetration to the whole country and thus bring a broadband revolution. The Government of India is helping rural areas to get connected through the Internet, and it is taking many steps to do it. For example, it is deploying fiber optic cables to the rural areas under the National Fiber Optical Networks (NFON), it is planning to deploy wireless Internet infrastructure in the rural areas, etcetera. TVWS can be used in such a way that devices at home will have an antenna at top of the house, and that antenna can communicate to the base station and controller. The rural teledensity is at 26% whereas the broadband penetration stands at a mere 1.5% of the number of telephone connection. High entry costs and low return on investment are serious disincentives for operators to service rural areas in the current scenario. The research that has been done so far studied availability and the technical aspects of the TVWS in India whereas this paper focuses on the cost that the user has to pay to get the Internet access and how much an ISP has to invest to provide Internet through TVWS. We have done detailed capital and operational cost analysis to deploy and operate TVWS. This paper discusses policies that should be included for using TVWS for Internet access in India. Overall this paper can be used by the Government, ISPs and, people to decide whether TVWS should be used for the Internet access[3].

III. FINDING THE WHITE SPACES: INSTANCES OF TVWS AVAILABILITY

TVWS can arise different ways at any given location. Nonetheless, the amount of spectrum available in the form of TVWS will depend on various factors, including: the level of interference potential to the incumbent TV broadcasting service, geographical features,TV coverage objectives and related planning, and television channels utilization. These and other instances of TVWS availability can be categorized (not restricted to) as follows:

a. Frequency: idle channels of a TV band plan in some geographical areas by means of frequency separation (guard channels).

b. Height: defines the availability of TVWS at a given area in terms of the height of the TVWS transmission site and its antenna height, in relation to surrounding TV broadcasting coverage reception.

c. Space: geographical areas that are outside the current TV coverage and therefore no broad-casting signal is currently present[4].

IEEE TVWS STANDARDS

The standardization activities in TVWS began in 2004. They were formulated to provide PHY/MAC layer solutions to enhance the deployability and enhance operational efficiency of TVWS networks. The standards were saddled to design environment specific architecture meeting end–users QoS expectation. The various standards have evolved each modifying the PHY and MAC (bandwidth, transmission power, system architecture, deployment scenarios) layer protocols to suit their targeted clients. The focus of this section is to highlight the various TVWS standards expected to populate the TVWS spectrum.

1)IEEE-802.22 Wireless Rural Area Network (WRAN)

The IEEE 802.22 standard was specifically established to provide wireless broadband access to rural and hard to reach areas, hence the acronym Wireless Rural Area Network (WRAN) [4]. IEEE 802.22 Working Group (WG) mandate was to develop physical (PHY) and medium access (MAC) layer specifications based on point-to-multipoint (PMP) WRAN topology. IEEE 802.22 is aptly designed for the rural areas based on the premise that there are lots of TVWS in the rural areas and also, the sparse location of consumers in the rural areas makes no economic sense to deploy other legacy standard.

2) IEEE-802.11 af Wireless Rural Area Network (WRAN)

The IEEE 802.11 af is a modified version of IEEE 802.11 but the main difference is that it operates in TVWS frequency band. Consequently, has an inherent characteristic of longer range and is equipped with CR properties. Hence the name "Super Wi-Fi". The 802.11af can compete with Worldwide interoperability for microwave access (WiMAX) IEEE 802.16 standard in-terms of range.

IV. TV WHITE SPACE FOR RURAL BROADBAND IN INDIAN SCENARIO

A good candidate for rural broadband in India is TV white space. In fact there is no much need of very large spectrum for broadband in rural areas as the density is very low. Spectrum scarcity is always the problem of an urban area.

Advantages of Sub-Giga Hertz Signals

Long-distance Communication

UHF and VHF signals in sub Giga-Hertz (frequency < 1GHz) spectrum have favorable properties that makes long-range (10 to 100Km) communication possible. At these wavelengths a signal transmitted at a given power level suffers lower attenuation and hence can be received intelligibly at receivers further out from transmitter.

Non Line-of-Sight propagation

Sub Giga Hertz signals can also undergo diffraction (bending) around corners/edges of obstructing features such as buildings, trees and hilly terrain in the inner Fresnel zone. This allows Non-Line-of-Sight (N-LOS) communication.

TV White Space: the master-stroke needed for Digital India White Space for Last-Mile Rural Broadband

As per NOFN plan a GPON (Gigabit Passive Optical Network) will terminate at each Gram Panchayat (GP) building. The diagram below shows how a TV White Space (TVWS) solution can enable wireless broadband connectivity for individual user premises spread across the village. At the GP a TV White Space (TVWS) Base Station will be fed by the optical backhaul equipment Optical Line Terminal (OLT) which would give out a 100M/1G Ethernet to a TVWS Base Station. The Base Station has a bi-directional RF interface (Up-link and Down-link) compliant to the IEEE 802.22 standard. This RF signal interfaces over a coaxial cable to a tower mounted omni-directional antenna that will transmit the wireless broadband signal to multiple user equipment within a range of 10 to 100Km depending on antenna height and transmitted power. User premises will have directional Yagi-type antennas mounted on roof-tops and which will feed the Customer Premise Equipment or Modem compliant to IEEE 802.22 standard. The Modem will then distribute the broadband within the user premises using standard LAN protocols such as Ethernet or WiFi.

White Space to fill gaps in Fiber to un-reached villages

TVWS technology can help reach broadband to villages that do not have an Optical Fiber reaching them. Here TVWS will operate as a wireless relay in Point-to-point (P2P) mode of operation. In this mode at each relay location there would be a TVWS Relay equipment that would communicate with the back-haul (towards optical network) and with the front-haul that would reach the remote village. Multiple TVWS Relays can operate in cascaded fashion to reach difficulties of terrain[6].

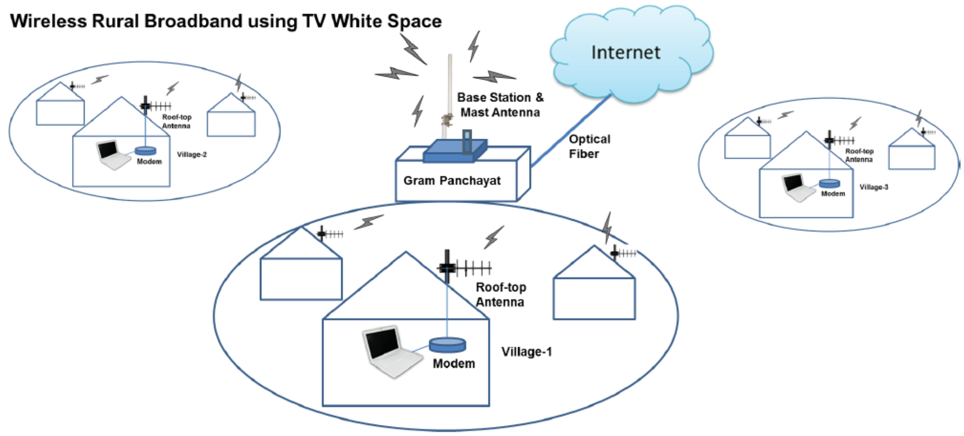


Fig Shows 4.1 TVWS for Rural Broadband

Benefit of White Space over alternatives

A Launchpad for Triple-play Services

Together with DTT, TV White Spaces offer an excellent mode to deliver triple-play services to rural areas. Broadcasting companies can now offer not only Broadcast TV or Mobile TV but also Broadband and Voice using VOIP technology.

Lower Capex costs

Rural areas are characterized by sparse population density, where small population is spread over a large area. Long distance reach of White Space technology allow a smaller number of Base Stations to cover such users, compared to shorter range technologies such as Cellular 3G/4G.Due to this it is estimated that White Space infrastructure would incur one-tenth the cost of deployment.

Lower Opex costs

Due to its lower power consumption TVWS broadband equipment could be solar-powered which would reduce its operating expenses as well.

Ease of installation/maintenance

Because it is a Wireless technology there are no issues with right-of-way or cost of digging, repair or replacement that would occur with Optical Fiber installation.

WiFi for Last-mile

WiFi standard was designed primarily for indoor LAN usage with short distance coverage (100 meter range). Some solutions attempt long range outdoor coverage by increasing radiated power which apart from creating health-hazards does not achieve the kind of range required for rural coverage. Due to its operation at 2.4GHz it is not capable of propagating well through walls, forests, hilly terrain. Another major drawback with WiFi is that it operates on the CSMA/CA protocol ("Listen-before-talk") due to which more than 5-10 users leads to fast degradation of service and poor data rate due to increased "collisions" between user traffic. This leads to poor end-user data rates.

Cellular for last mile

3G/4G Cellular technologies were designed for city usage with high-density coverage. These base-stations have a short-range, so it would need a large number of base-stations to cover sparsely populated rural areas. This means larger investments are required to reach rural users. Even developed countries like US with good cellular network coverage in cities have rural populations that have zero coverage because telecom companies find it unviable!This is one reason for emergence of TV White Space technology to address their rural broadband coverage issue.

An umbrella of Drones, Balloons and Satellites…

There are other futuristic options being investigated to address the Last-mile gap. Facebook is exploring use of an umbrella of Drones and Satellites. Google is looking to use high-altitude Balloons. However all of these are not near-term solutions and even if they succeed will take 10 years to mature and be available at affordable costs.

Make Digital India in India!

Perhaps for the first time in history India has a lead in developing a Telecom standard like TV White Space. Indian academia and industries have played an important role in development of TV White Space standards and have already developed products for the world market. As the rural broadband gap is a world-wide issue India can not only cater to its domestic market but also export these products to countries like USA, UK, Korea,Nigeria, South Africa, Philippines, Singapore [7].

OPPORTUNITIES AND CHALLENGES IN WHITE SPACES FOR RURAL BROADBAND

"Network based" with the devices under control of the base station that provides the connection which is back to the database.

The scope and feasibility of circular cell concept for enhancing rural broadband is very limited. It is because of changing terrain conditions in any particular area. In order to exploit the white space opportunities, the database should be initially created by using RF propagation models. Periodic updates should be provided by the base stations to the CR devices. There should be constant monitoring of spectrum with the help of spectrum sensing techniques. Once a data base is being created there are immense of opportunities. Doordarshan is the primary licensed user for almost the entire television frequency band. Government regulations have to be made in order to avail this spectrum for the secondary users. Also, the secondary users should be able to guarantee the primary user that there will not be interference of any sort while using the spectrum.

Another challenge in this respect is that the secondary users providing rural broadband would be reluctant to invest billions for a temporary solution for the spectrum. The secondary users will be happy only if they get the spectrum for the entire lifespan of their service. Also there is a migration of channels from digital broadcasting to the transmission through optical fibres. Thus the service providers are waiting for better opportunity for the so called digital dividend[8].

V. CONCLUSION

In Wireless communication the unutilized TV White Spaces presents a great opportunity for a better coverage and substantial bandwidth for the broadband communications.This Paper serves as a starting point towards the development TVWS and white space for rural broadband connectivity and better utilization of white spaces in India. A study on combining both geolocation databases and spectrum sensing for TVWS access will be the major agenda of our future work.

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