# Broadband Connectivity to Rural masses using TV Bands in India

**Author: Mayank Kumar**
**C.T.O. Yantrr Electronic Systems**

## Introduction

The introduction of mobile and the power of internet have changed the way people talk, purchase, plan and connect to others. In the last decade, mobile voice and messaging has become catalyst for economic and social xdevelopment brings out new ways for businesses to reach to new customers. Data services and mobile internet on the other hand has given a new meaning to social and business networks. From value added services over internet like online banking, online train and air ticket to social networking like Facebook has added a new dimension to the way people approach to their daily activities. Referring to the report of World Bank[1], a 10% increase in broadband penetration accounts for approximately **1.38 percent** increase in per capita GDP growth in developing countries. This is even higher than the impact of mobile telephony on GDP.

Though these changes are revolutionary, only a smaller segment of the population – those living in urban and sub-urban areas could reap in its benefits as broadband penetration in large part of the developing world is limited to only urban areas having high density population. Eg in India broadband penetration is only 1.05% current mobile penetration is as high as 71.11%. Though mobile penetration is high, broadband services provided using mobile network (EDGE, HSPA etc) are too costly to be afforded by rural masses.

Though government bodies have launched several programs to provide the backhaul – eg Indian government decided on June'11 to set up national optical fiber network to connect all village panchayat. Still, the last mile connectivity has to be established by network operators using either optical fiber (FTTH) or copper cable (DSL). These solutions have high capex and opex cost. Also, as the density of population is low in major rural and semi-urban areas, the ROI for broadband service provider is even lower. Thus, there is an urgent need to find technology solutions (particularly wireless) which has long

[1] IC4D 2009: Extending Reach and Increasing Impact.

coverage area and high data throughput to serve large areas and at the same time make viable business model for telecom operators.

## TV Band spectrum - A possible solution

Traditionally, broadcast TV transmission takes place in UHF and VHF range in a 6-8 MHz band per channel. But, these band of frequencies which occupy different slots in the frequency range from 470-698 MHz, remain highly underutilized. Their usage pattern change with geo-location, and in rural and semi-urban areas, they are mostly unutilized owing to fewer broadcasters and licensed microphone users. Apart from these, there are protective bands of unused spectrum (white space) between bands occupied by TV signals originally serving the purpose of preventing interference. These guard bands will not be needed with the newer digital technology replacing older analog TV signals.

Due to the lower frequency associated with these white spaces signals, these could travel much further **(30-50 Km)** and can easily penetrate through buildings, vegetation's, and other objects. With relatively low level of industrial noise and ionosphere reflection, reasonable antenna size, and good non-line-of-site (NLOS) propagation characteristics, these are economically and technologically ideal for covering sparsely populated rural and sub-urban environment for broadband access, tele-education, telemedicine and other economic and social growth oriented services.

Our studies of TV band spectrum allocation in India (National Frequency allocation Plan, 2008[2]) reveal that large band of frequencies (470 MHz – 698 MHz) are allocated for TV transmission (refer table 1). 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.

**Table 1: TV Spectrum allocation in India**

| Frequency Band | Proposed Usage |
|---|---|
| **368-380 MHz** | Fixed Mobile Band<br>*Could be considered for **rural communication** on case-by-case basis* |
| **380 – 400 MHz** | Public protection and disaster relief (PPDR) |
| **406.1 – 430 MHz** | Public protection and disaster relief (PPDR) |

[2] ***National Frequency Allocation Plan - 2008***. New Delhi : Ministry of Communication and Information Technology, Government of India, 2008

| | |
|---|---|
| **440 – 470 MHz** | Public protection and disaster relief (PPDR) |
| **470 – 520 MHz** | Fixed and mobile services to be considered on a case-by-case basis |
| **520 – 585 MHz** | Fixed and mobile services to be considered on a case-by-case basis |
| **585-698 MHz** | Broadcasting services which include mobile TV |
| **698 – 806 MHz** | IMT and Broadband wireless Access (BWA) services in 698-806 MHz may be considered for co-ordination on case by case basis **(4G based)** |
| **806-824/851-869 MHz** | Public protection and disaster relief (PPDR) |
| **890 – 960 MHz** | Mobile Cellular Services (GSM) |
| **824-844 / 869-889 MHz** | Mobile Cellular Services (CDMA) |

Moreover, all these analogue TV channels will go digital in India by **March, 2015**[3]. This will lead to same type of digital dividend observed elsewhere in the world. Thus, more frequency bands will be empty in coming times which will add to the total whitespaces available in India.

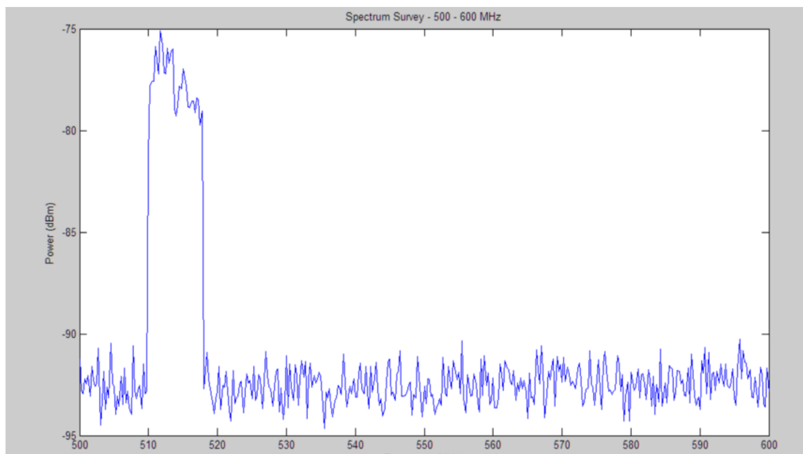



**Figure 1: TV Spectrum occupancy at IIT-Delhi**

In an extensive spectrum survey conducted at IIT Delhi (located in South Delhi (Figure 1) to understand the real usage scenario on 12th July, 2011, it is indeed found that most of the frequency spectrum (470-698 MHz) actually are lying vacant. Figure 1 shows spectrum capture of TV band from **500-600 Mhz** clearly showing that only 10 MHz of frequency band is occupied and the rest 90 MHz lie vacant Similar sweeps were done across the TV spectrum and found to be sparsely used.

Further the usage of spectrum has temporal and geographical variation, which again tells us spectrum is totally underutilized in rural area and sparsely utilized in urban. Here lies the resource which can be harnessed by intelligent technology to bring broadband revolution. Some of the key factor that assist TV bands to be the potential solution are:

A) Larger coverage area: 30 -50 KM
B) Underutilized spectrum

C) Less infrastructure cost
D) TV whitespaces due to digitization, hence more empty channels

With above most needed features, communication on TV band can help to achieve last mile connectivity with tiny cost of infrastructure.

## Regulatory requirements: Licensed or Unlicensed Bands?

TV bands are currently licensed band, hence regulatory norms doesn't allow any user to access those. The data over TV band can have both licensed and unlicensed model. Licensed models in which the network operator has the dedicated chunk of the TV spectrum from the underutilized TV bands and provide services in that band.

Unlicensed band is what creates business interest in TV bands. Unlicensed bands are mainly those channels (6-8MHz) which gets freed up after the digitization of TV services. Since these bands would be non-contiguous, these are termed as **TV white space**. Unlicensed nature of these scatted band means any one can use it, but it needs to be regulated so as not to cause harm to adjacent incumbent users.

There is an ongoing global effort in other parts of the world (FCC, USA and ECC, EU) to release these spectrum under innovative licensing regimes with an objective to encourage state-of-art wireless solution at low cost to the end users along the lines.

The general idea being developed is that these new devices called TV whitespace devices which are allowed to use the interleaved spectrum ("white spaces") in between TV channels are subject to the restriction that they will not cause harmful interference to incumbent services to which the band is allocated. Thus, such devices need to first obtain information about the available/unused channels before being allowed to transmit on locally unused channels.

In India, majority of TV channels are empty. State run terrestrial channels will act as incumbents which have to be protected from harmful interference. As discussed, the terrestrial TV channels will change from analogue to Digital (DTB-H) in **March, 2015**, freeing up more whitespaces between these TV channels. Other incumbent users could be microwave link users (BSNL/Defense) and microphone users operating during special programs.

Thus, it will be really crucial that these frequency spectrums are soon released, either under licensed or unlicensed regime to create the well-timed impetus for further economic and social development of the country.

## Technology Challenges

There are few unique technical challenges which need to be addressed before these unlicensed frequencies or "TV whitespace" could be used to roll out broadband services. Some of these challenges are related to these frequencies being used for other purposes like TV transmission, microphone users and defense as highlighted in the last sections.

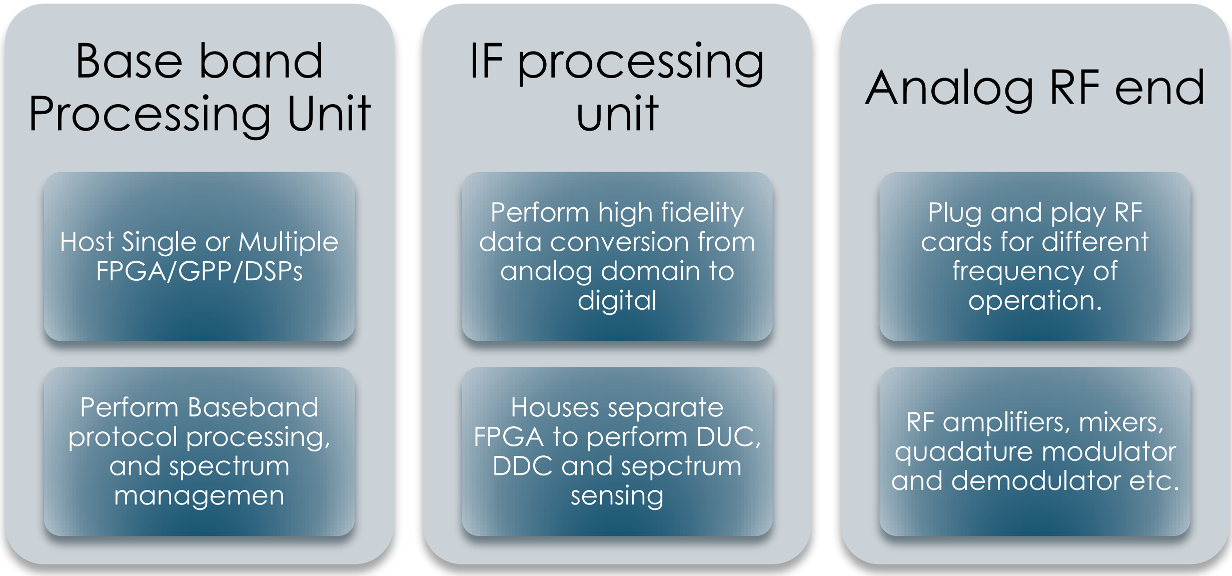
The major challenge is to detect the empty slot in the spectrum and use/share it for data services, with a caution that your device will relinquish the resource as soon as it detects an incumbent user. Such intelligence is required in the radio such that it can dynamically access the spectrum. Intelligent Radio or (**Cognitive Radio**) is one of the upcoming technologies which are attracting focus for dynamic spectrum access. As different frequencies could be vacant in different part of the country and at different times, conventional communication transmitter and receivers with fixed frequency of operation could not be used. So, **software defined radios (SDR)** in which frequency of transmission and reception, power of transmission, modulation scheme, error correction codes and channel model etc. are software programmable have to be used.

Depending on the regulatory requirements, different methods could be used to determine the presence of primary incumbent users like TV transmitters, microphone users etc. These methods could involve complex signal processing to perform spectrum sensing to detect the presence of incumbents. Alternatively, using geo-location database, the location of transmitter in an area could be found out anytime by referring to a database. All TV whitespace transmitters would know their location beforehand or use GNSS positioning system (GPS) to determine their location. This method could provide computational simplicity, but the database of primary and secondary users have to be centrally maintained. Though, a hybrid of both methods is most suitable for operation in diverse situations in real world scenario.

## SDR and Cognitive Radio at YES

**YES** is developing an SDR platform (Astitva™) which is ideally suited for conducting experimentations on TV whitespace. The platform being developed is highly modular in nature and could work in any other frequency range as well. A basic block diagram of the system is shown below for reference comprising of a baseband processing unit, an IF processing unit and an analog card which could integrate with any of-the-self RF frontend.

We are working closely with Indian Institute of Technology (IIT Delhi) for the research going on there in Wireless Regional Area Network (WRAN) based on IEEE 802.22 standard.




For further details and any SDR related query, contact

**Mayank Kumar**
C.T.O. Yantrr Electronic Systems Pvt. Ltd.
Email: mayank@yantrr.com
Website: www.yantrr.com

Mobile: +91999910525