Indian Institute of Technology Bombay

Proposal for TV White Space towards National Frequency Allocation Plan (NFAP) 2010

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EXECUTIVE SUMMARY

The contribution from IIT Bombay at the 23rd December 2010 NFAP review meeting [1] discussed the ongoing global developments in the sub-1GHz frequency spectrum.
This document proposes changes, in the form of novel concepts, to NFAP 2008 to adopt innovative approaches for the use of this spectrum in India. The primary objectives of the proposed concepts are as follows:

- To promote innovative approaches for spectrum access in India and reduce entry barriers for Indian entrepreneurs to provide wireless services and applications
- To maximize spectral utilization by increasing frequency reuse in spatial and time dimensions especially in those regions in India where spectrum usage is low
- To maximize cost-effectiveness of technology adoption to end users, especially for Indian rural users, and provide them with broadband services and applications at an affordable cost
- To ignite research in Indian wireless academia and industry that addresses the unique challenges for India's spectrum availability and utilization scenario

TV WHITE SPACE BANDS IN US AND EUROPE

Transition from analog to digital television is resulting in an opportunity for reallocation of the spectrum that is being used by analog television systems (also referred to as digital dividend). There is an ongoing global effort to release this spectrum under innovative licensing regimes with an objective to encourage state-of-the-art wireless solutions at low costs to the end users along the lines.

Table 1: Regulatory scenario for TV White Space spectrum in US and Europe.

	US	Europe
TV White Space (licensed)	698 – 806 MHz (Auctions completed [1])	790 – 862 MHz (auctions pending) [550 – 606 MHz] (under consultation) [2]
TV White Space unlicensed (lightly licensed*)	Total of 282 MHz in 54 – 698 MHz range (ruling completed Sep'10 [3]) Note: Refer to reference for exact bands	[470 – 550 MHz 614 – 790 MHz] (under public consultation) [4]

*Lightly licensed bands will require unlicensed radios to adopt cognitive concepts to ascertain the presence of licensed or primary users of the band

Data in Table 1 shows that majority of the TV White Space spectrum in US and Europe are being regulated to operate under unlicensed or lightly licensed manner to provide platform for innovation in wireless industry. This innovation will create methods to provide future broadband wireless services and applications to people at a lower cost.

SITUATION IN INDIA

NFAP 2008 mentions the following for frequency band 470 – 698 MHz:

- 470 – 585 MHz: to be considered for fixed and mobile services on a case-by-case basis
- 585 – 698 MHz: predominantly in use by broadcast services including mobile TV

It is noted that the above bands have been primarily assigned for terrestrial broadcasting which is in line with the situation in other parts of the world.

DEFINITIONS

White Space [6]

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

Cognitive Radio [7]

Cognitive radio system (CRS): A radio system employing technology that allows the system to obtain knowledge of its operational and geographical environment, established policies and its internal states; to dynamically and autonomously adjust its operational parameters and protocols according to its obtained knowledge in order to achieve predefined objectives; and to learn from the results obtained.

White Space Device

White Space Devices (**WSD**) are devices that can use White Space spectrum without causing harmful interference to protected services by employing required cognitive capabilities.

USE CASE SCENARIOS

There is potential for shared use of the India's TV White Space spectrum by several applications. Three classes of short and longer range devices can be considered for interleaved deployment in this spectrum:

- Personal/portable devices, such as Wi-Fi cards in laptop computers, smart phones, PDA's, personal media players, which operate with, for example, a maximum power output of 100 mW.
- Fixed/access devices that are generally operated from a fixed location and may be used to provide a commercial service, such as wireless broadband Internet access. These devices could operate with, for example, a transmitter output power of up to 1 W.
- Mobile devices that will provide mobile broadband services and applications

Similar categories of devices operate today in 2.4 GHz and in 5 GHz bands. However the sub-1GHz frequencies offer more favorable propagation characteristics resulting in better coverage with reduced infrastructure requirements for services such as broadband Internet access. This is especially important for broadband access in rural areas.

RECOMMENDATIONS FOR INDIA

Firstly we express our sincere appreciation for this opportunity granted by WPC to accept recommendation and proposals for NFAP revision. To this effect we recommend that the frequency 470 – 685 MHz be considered for lightly licensed operations as per the proposal outlined in the following section. It is our view that such a move will make most efficient use of TV white Space spectrum in India in addition to offering tremendous benefits to the Indian industry and end users alike. More specifically, the regulatory requirements for such band should provide the following benefits to Indian citizens

1. Ample opportunity to Indian academia and industry to develop home grown technical innovations to create India's own intellectual property for methods used for TV White Space spectrum usage and access
2. Provide telecom Indian Standard Organizations (SDOs) the platform to develop specifications that is in the best interest of Indian citizens and industry. This will not only jump start a new era of Indian wireless technology and industry similar to the wireless standards and industry of other countries such as US, China as well as European Union but for the first time develop an Indian standard for TV White Space addressing the unique challenges faced by Indian wireless industry including but not limited to India's vast rural population.
3. Provide opportunity for new rural and urban entrepreneurs in wireless industry to provide low cost devices and services to address the unique scenario of India where majority of Indians live in rural areas and have very low per capital income
4. Facilitate research and development in wireless industry in India

In order to ensure that India's TV White Space spectrum provides unique and most needed benefits to Indian citizens described above, we strongly recommend that TV White Space spectrum in India be lightly licensed.

Moreover since licensed or primary users operating in this band in India are similar to those operating in other geographies, we recommend harmonizing with spectrum access rules being considered in other regions such as US and Europe. A brief summary of the technical details have been included in the Annex.

PROPOSALS

As per the discussion included above, we propose the following:-

- Consider a phased approach in introducing new technologies in the TVWS band: Adopt a geo-location based database approach in the near term. However since sensing and beacon propagation have the potential to significantly improve spatial reuse of frequencies, we propose to closely follow international developments pertaining to these techniques and develop home grown technology and specifications as well as selectively adopt advanced techniques developed by other SDOs as and when they become available.
- Since we expect WSDs to use variants of OFDM technology, we propose to define power limits similar to license-exempt operation allowed in 2.4 – 2.4835 GHz as per GSR 45E.
- In order to guarantee interference protection to licensed users, we propose that WSDs must implement features such as adaptive power control to minimize possibility of in-band and out-of-band leakage to primary users.
- Limits should be defined in terms of PSD to avoid possibilities of multiple WSD's sharing a common TV channel by using narrow operation bandwidths at higher power levels.
- The in-band and out-of-band emission limits and protection distances be defined as per categorization of the WSDs i.e. fixed outdoor WSDs will have greater interference potential than WSDs that are intended to be operated indoors.

REFERENCES

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APPENDIX

Cognitive Techniques for White Space Devices

Spectrum Sensing

With spectrum sensing, devices try to detect the presence of protected services in each of the potentially available channels. Spectrum sensing essentially involves conducting a measurement within a candidate channel, to determine whether any protected service is

present. When a channel is determined to be vacant, sensing might be applied to adjacent channels to determine what constraints there might be on transmission power, if any.

Key parameters for spectrum sensing include:

- Sensing threshold
- Periodicity of re-sensing on channels that have been detected as vacant
- Sampling duration

A significant advantage of spectrum sensing (stand alone) would be that it does not rely on any existing local infrastructure, such as connection to a database or a beacon. This could be important in remote and rural areas. However, if sensing thresholds are to be set very low in order to protect existing services, this will result in increasing device cost and complexity as well as a reduced number of available channels. This would reduce the potential value to end users, particularly in areas of higher population density, and would hinder commercially viable deployment of the WSD technology.
So far analyses of sensing performance assume that detection is carried out independently by each device, in ignorance of results found by other cognitive devices in the same location. The emergence of cooperative sensing, in which devices share their findings, may bring in the future the potential to improve sensing reliability.

Geo-location database

In this approach, cognitive devices measure their location and consult a "geo-location" database to determine which frequencies they can use at their location (location which they have indicated to the database). Parameters such as location accuracy and frequency of database enquiry are important. As an example, the accuracy of the location measured by a WSD installed under the control of an operator is expected to be better compared to an ad hoc installation.

The devices are not allowed to transmit until they have successfully determined from the database which channels, if any, are available in their location. This requires that the initial access to the database is done either using a channel reserved for this purpose or by some other means.

In some cases, for example in the case where a WSD is connected to an access point, one WSD may act as a proxy for the database queries for another WSD or a set of other WSDs. The querying WSD would be called the master WSD and the WSD(s) it does the query for would be called slave WSD(s). In this case the master WSD would have to ensure in an appropriate way that the slave WSDs operate according to the constraints returned by the database. Depending on the particular implementation this may require that the master WSD has some form of control over the operation of the slave WSDs.

Beacon

Beacons are signals which can be used to indicate that particular channels are either in use by protected services or vacant. The use of beacons can ease the performance requirements on devices that use spectrum sensing, by increasing the likelihood of detection at higher threshold values. The interference protection provided to licensed

users comes at a cost in spectrum capacity as well as the cost of purchasing and operating the beacons.

There are various possible beacon setups possible:

- Enable beacon: If the beacon is detected, the considered channel can be used. With enabling beacons, a network of beacon transmitters covering an entire country or region in which WSD are allowed to operate would be required. The WSD would only operate when they received authorization from one of these beacons. Each device would need to be fitted with a beacon receiver, and fine-grain control over individual devices would not be possible without a back-end database.
- Disable beacon: If the beacon is detected, the considered channel is occupied and cannot be used by WSD.
- Beacon as pilot channel: identifies locally used TV channels, i.e. local database.

There have been no detailed proposals on this approach but there may be scenarios where such an approach may have great merits.