

Fresh Approaches to Spectrum Sharing and Emerging Regulatory Rules in the TV Band WhiteSpaces

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WhiteSpace Alliance Mission

WhiteSpace Alliance™ was launched in Dec. 2011.

The mission of the WhiteSpace Alliance is to:

- Act as a *technology neutral organization and a catalyst* in shaping the worldwide Whitespace ecosystem for delivering cost-effective wireless broadband solutions.
- Simplify existing standards and specifications for cost-effective deployment in WhiteSpaces –
e. g. WSA will support *IEEE, 3GPP, IETF and other Standards* for operation in WhiteSpaces across the spectrum.
- Make enhancements where required.
- Educate and spread awareness in various countries as to the benefits of WhiteSpace spectrum
- Inter-operability, certification and testing of WSA waveforms and products™



Worldwide Opportunity – 3.5 Billion Customers

PROVIDING COST-EFFECTIVE BROADBAND AVAILABILITY IS A SIGNIFICANT OPPORTUNITY

- Currently, 73% of the world population (5.1 Billion people) has No Internet Access
- 49.5% of the 7 Billion people in the world (~3.5 Billion) live in rural areas.
- It is expensive to lay fiber / cable in rural and remote areas with low population density. Wireless is the most economically viable solution
- Urban areas can also benefit from the WhiteSpace Solutions (e. g. off-loading cellular traffic, smart grid solutions etc.)

Other Machine to Machine Applications will Drive Up the Volumes More than 20 Fold



Spectrum Sharing Domains

- **Advanced Receiver Technologies can allow co-existence in**
 - Space, Time, Code, Frequency
- **White as well as Gray Space Operation** is not just a possibility but can become a reality through proper and carefully crafted system design steps
- **Co-existence can be enabled through**
 - Avoidance - e. g. Dynamic Spectrum Access, Dynamic Frequency Selection
 - Tolerance – Modulation, Coding etc.
 - Suppression – Beam-forming, Beam-nulling etc.
- **Spectrum sharing is a two way process** – Just as commercial systems want to use federal spectrum perhaps federal systems can also share spectrum that will be opened up to commercial systems – *e. g. TV Whitespaces for maritime communications for the coast guard*

A. Mody et al. “Machine Learning based Cognitive Communications in White as well as the Gray Space”, MILCOM 2007



Spectrum Sharing Enablers

Co-existence Enablers: In general, three techniques are widely accepted to enable spectrum sharing -

- **Spectrum sensing** based detection and avoidance,
 - Pro - Spectrum sensing and signal classification techniques can efficiently detect / classify various kinds of friendly and un-friendly signals. Real time operation possible
 - Con - Sensing techniques are not reliable at low SNRs required when systems operating with large and different dynamic ranges are present; and susceptible to hidden and malicious node issues.
- **Spectrum Database** (e. g. in the Television Band WhiteSpaces)
 - Pro - Database driven approaches are highly reliable when available information is reliable and not dynamic. Cloud computing exists today and works
 - Con – Database driven approaches are as reliable as the data that is provided to it. Needs eyes on the ground to authenticate the reliability of that information. Real time operation doubtful.
- **Beaconing** (e. g. the IEEE Standard 802.22.1-2010).
 - Pro - A well designed and secure beacon can provide substantial gain in low SNR conditions and ability for systems to reliably detect and decode it without the hidden or malicious node issues. Real time operation possible.
 - Con – Susceptible to interference and replay attacks

Radar, Commercial Comms Spectrum Sharing in 3550-3650 Bands in the US Using IEEE 802.22.1 Advanced Beacons

Objective To Create NATIONWIDE availability of the 3550-3650 MHz Band using IEEE 802.22.1 advanced beaoning approach

Current Plan: The current plan is the use of exclusion zones to protect U.S. Navy coastal operations and other Department of Defense test and training areas. This means that major part of the US population will not be able to use these bands.

Alternatives: However, there may be some other approaches which will make 100 MHz of spectrum available nation-wide, and especially in the coastal areas where significant US population resides.



Background

3550 – 3650 MHz Band: One of the portions of the spectrum identified to achieve the goal of freeing up 500MHz of spectrum, is the 3550-3650 MHz where maritime radars have been deployed.



Approach

Use of Advanced Beacons Approach: Neither spectrum sensing or database driven approaches are suitable for this type of spectrum sharing. However, *advanced beaoning approaches, such as the one developed in the IEEE Standard 802.22.1 for spectrum sharing between the primary signals and incumbent signals may be used* for the 3550-3650 band.



Deployment Strategy

Regulators have realized that beaoning is a viable option for spectrum sharing. *The IEEE 802.22.1-2010™ standard has been completed and can be amended for protection of radars and satellite earth stations*

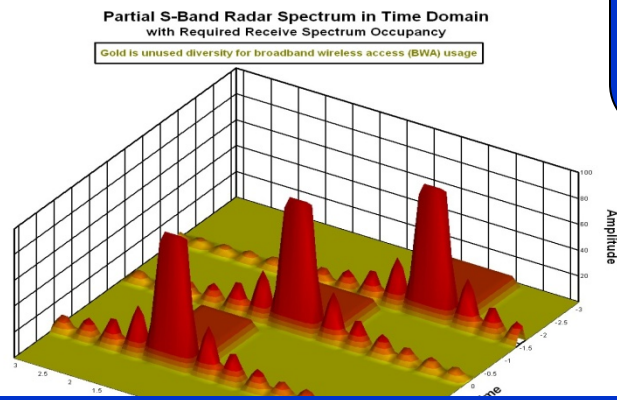
Presenter: **Dr. Apurva N. Mody**, Chair, IEEE 802.22 Working Group, Chairman, WhiteSpace Alliance™
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Presenter: **Mr. Ken Carrigan**, US Navy, NAVSEA, Dahlgren, VA
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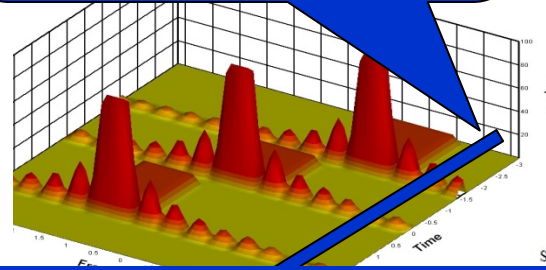
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Radar, Commercial Comms Spectrum Sharing in 3550-3650 Bands Using IEEE 802.22.1 Advanced Beacons

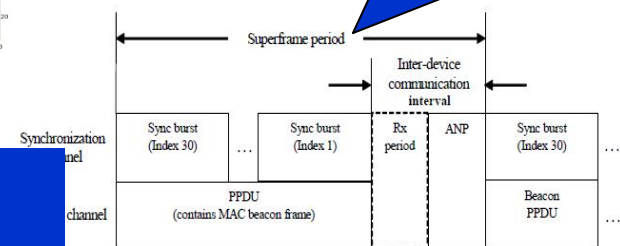
- **How will it Work:** The designed beacon will contain *Peace Time* temporal patterns of the radars which when combined with some universal time clock such as GPS can help commercial communications systems to use the empty time slots for their operation.
- During *Emergency Situations*, the beacon will send Urgent Co-existence request, to ask all the commercial systems to shut down immediately. Security features for such beacons are very important. IEEE Std, 802.22.1-2010 has incorporated many such security mechanisms that may be applied to the 3550-3650 band relatively readily.



IEEE 802.22.1 Like Beacon may operate in the same band or even UHF Band



Current IEEE 802.22.1 beacon protocol contains many security Features already



This approach can open as much as 600 MHz of Spectrum in the S-Band

Emerging TVWS Regulations Around the World

Canada Regulations completed – Total 300 MHz (Ch. 2-51) being considered for license-exempt operation, of which 180 MHz (ch. 21-51) have already been open for light-licensing for remote rural broadband access since June 2009



USA Regulations completed – Total 288 MHz freed up (Sept 2010) for license-exempt operation. Geolocation database, sensing optional. Some spectrum will be auctioned off

Brazil – DTV transition on-going. Realizes the importance of broadband for rural (e. g. Res. 558, Operation in 450 – 470 MHz)



UK Initial Rules Released (July 5th, 2012) – License-exempt database driven approach, different classes of devices, sensing optional



EU (CEPT) Discussions on-going – license-exempt, collaborative sensing, database approaches considered. Variable transmit power based on device capabilities, microphone

Egypt – interested and participating in IEEE 802



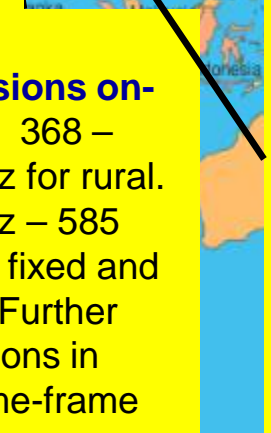
Japan (MIC) Discussions on-going Final rules before 2015. 10 WS projects under way – WS Test Area to be allocated



ITU – Several study groups are discussing cognitive radio based operation. TVWS may be a discussion topic in 2015 WRC. IEEE 802 is providing inputs

India Discussions on-going – 368 – 380 MHz for rural. 470 MHz – 585 MHz for fixed and mobile. Further discussions in 2015 time-frame

Singapore Testing devices on-going (IDA)– Final rules before 2015. 12 channels for testing. May allow bonding of up to 8 channels. Sensing, database required



Highlights Comparing of Emerging TVWS Rules in Different Countries

Common features across most countries

- Database service driven approach required - In general White Space Devices (WSD) will provide their location, antenna height and power, and they will receive the available channels that they can use
- Spectrum sensing is encouraged but not required.
- In general, operation is divided into high power (4W radiated) fixed devices and low power (typically 100 mW) portable devices
- The required location accuracy is defined and new channel assignments are required if the devices move by +/- 50 m
- All WSDs must meet the regulatory defined transmit spectrum mask
- WhiteSpace operation to stop if connection to the database service is lost.

Key Differentiators Between Various Rules

Canada Regulations completed

– Remote rural broadband system (RRBS) BS can transmit with 500 Watts of power in TV Bands. Light licensing approach allows access to spectrum at few hundreds of \$. Spectrum mask is very easy to meet but does not allow operation up to two adjacent channels. Harmonization with US proposed in future

USA TVWS Regulations – US was the first one to establish the rules. Rules are conservative but that is the advantage / disadvantage of going first. Database service is PULL only. No PUSH right now. Absolute values for spectrum mask in the third MO&O. WSDs can operate up to 24 hours even after loss of connectivity with the Database

UK Initial Rules Released (July 5th, 2012)

– Pull and PUSH mechanism for database service. Master and Slave WSDs to cease transmission within 60 seconds once instructed by the database. Several classes of devices created with their own spectrum mask. Variable EIRP based on location and class of the device. Also studied the effects of ON/ OFF transmitter effects on TV receivers and mask defined accordingly.

Singapore (IDA)– Final rules before 2015. Database AND spectrum sensing is a requirement. Can transmit on up to 8, 8MHz channels. The proposed spectrum mask is even tighter than the one proposed in US and UK. Spectrum sensing requirements are tougher than the ones proposed in US

Conclusions

- We provided overview of WhiteSpace Alliance
- *We proposed an Advanced Beacons Approach*: Advanced beacons approaches, such as the one developed in the *IEEE Standard 802.22.1-2011 for spectrum sharing between the primary signals and incumbent signals* may be used for the 3550-3650 band.
- *White as well as Gray Space Operation is not just a possibility but can become a reality* through proper and carefully crafted system design steps
- *World-wide spectrum sharing rules* starting with TV Band WhiteSpaces are emerging
- *Small countries such as Singapore and Japan are pushing* to create technologies and enablers for White and Gray Space operation
- *WhiteSpace Alliance™ has been formed* to cater to the emerging WhiteSpaces eco-system and is actively seeking new members.

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