TV White Spaces: A Geolocation Database Platform to Govern Shared Use Spectrum

ISART


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What are TV White Spaces?

- Unassigned TV Channels – they are unoccupied channels in a given area.
- Many freed as a result of the Digital TV Transition (e.g., in US, UK)
- Channels vary widely by market – few in largest metros, more in small towns/rural areas
- Useable on an unlicensed basis for broadband applications (e.g., WiFi and as wireless backhaul), narrowband M2M, etc. Both Fixed and Portable.
- Much lower frequency than current WiFi (below 700 MHz)
- Signals cover far larger areas than WiFi and penetrate or bend around obstacles (trees, hills, deeper indoors) relative to higher frequencies
Location, Location, Location: Lower Capex, Better Coverage < 1 GHz

- Mobile/non-line of sight
- Fixed/line of sight

Normalized Network CapEx

- Fixed Outdoor CPE
- Fixed Indoor Self-install CPE
- Anywhere Nomadic

Frequency (MHz):
- 700
- 1900
- 2400
- 3500
- 5800

0 2 4 6 8 10 12
**TVWS Spectrum Availability**

- Available spectrum varies by location
- In rural areas many channels are available
- In big cities only a few channels may be available – and often none at all for fixed wireless able to operate at full Part 15 power
- Examples of availability in UHF channels 21 – 51 (Illustrative):

<table>
<thead>
<tr>
<th>Channel</th>
<th>New York</th>
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In less dense areas many channels are available.
For example: Wilmington, NC: 25 total WS channels = 150 MHz
Lexington, KY: 28 non-adjacent channels = 168 MHz (10 + 15 contiguous)
Personal/Portable Devices:
Must Check Geolocation Database for Available Channels in Area

- Power limit: 100 mW except only 40 mW on channels adjacent to TV
- May operate on TV channels 21-51, except channel 37
- Mode 1 device obtains channels from a base station or device w/ Internet access
- Mode 2 device obtains channels direct from database
- Mode 2 devices re-check daily
- Mode 1 devices must contact, or receive a contact signal from, their fixed or Mode 2 device at least once per minute

Mode 1: Portable device obtains location/channels from fixed device

Mode 2: Portable device uses its own geolocation/database access capability
Fixed Wireless Devices: Base Stations at Part 15 Power Using Second Adjacent Channels (per TVDB)

- Must avoid use co-channels and first-adjacent channels
- Can use Chs 5 – 51 (except 37) at max. 4 Watts EIRP
- Must access database at least once a day to verify channel availability
- 250 meter HAAT max. for tower site & 30 m AGL max. for base stations – but overall height cannot exceed 250 m HAAT

Wireless Broadband (WISPs)
- Higher Power Fixed (Last Mile)
- Wireless Backhaul

Machine-to-Machine
- Remote Sensing and Monitoring
- Smartgrid AMIs
- Mobile Video Surveillance
How We Got Here

‘What a Long, Strange Trip It’s Been …’

- 2002: Spectrum Policy Task Force → Notice of Inquiry
- 2004: First Notice of Proposed Rulemaking (NPRM)
- 2006: Bipartisan Legislation → WS Testing Timeline Set
- 2008: FCC Adopts Report & Order (5-0 vote)
- 2010: FCC Adopts Final (Recon) Order (5-0)
- 2012: Spectrum Bill Enacted (“Incentive Auctions”)
- 2012: Final Recons Resolved – Devices/DBs Certified
Incentive Auctions
- Voluntary participation by TV stations determines how many MHz/Channels can be cleared for auction
- Broadcasters not participating compensated for channel relocation

FCC Repacking Authority
- FCC determines how to reorganize the TV Band
- Negative provisions on unlicensed dropped
- Vacant TV Channels remain unlicensed – market-by-market
- Will there be “triples” (high power fixed channels) left for WISPs?

Auction Band Plan: Contiguous Unlicensed
- FCC discretion to designate LTE gap/guard bands for unlicensed nationwide
- Duplex gap/guard bands must be “technically reasonable”

3550-3650 MHz not mandated for auction

Potential 195 megahertz of unlicensed spectrum in 5 GHz
Currently operational TVWS trial deployments supported by Spectrum Bridge, Microsoft, Google and other companies.

- **Rural Broadband**: Nation’s first TVWS network – Claudeville, VA
- **“Smart Grid” Network Deployment** – Plumas-Sierra Rural Electric Co-Op, CA
- **“Smart City” Network Deployment** – Wilmington, NC
- **Telemedicine Applications** – hospital campus – Logan, OH
- **Tribal and Public Safety Remote Area Deployment** – Yurok Reservation, Arcata, CA
- **Super WiFi Network Deployment** – Cambridge, England – and 2 Spectrum Bridge networks in Finland
  
  In UK, 1-year trial: package of use cases by consortium 14 companies (Microsoft, BT, BBC, Neul, Nokia, Adaptrum)
What’s Next for White Space?

Smart grid communications: Wireless Meters

- EU: Cellular NANs
- US: Unlicensed NANs and HANs
- Faster deployment of advanced meters

AMI Node Shipments
Q1 2011
Pike Research
What’s Next for White Space?

Mission Critical: Wireless Healthcare

- WiMax: 2%
- UWB: 2%
- Zigbee: 4%
- RFID: 9%
- Bluetooth: 31%
- Cellular-Licensed: 17%
- Wi-Fi: 34%

Market share
Wireless Healthcare
Kalorama Information
September 2011
M2M Networks: Smart Home, Mobile Payments, Inventory
HetNets: Mobile Carrier Offload

The Ruckus solution for a Wi-Fi and LTE small cell integrated network supported by Smart Mesh backhaul.

Ruckus sells 100,000 hotspots to KDDI.
Wi-Fi is Already Offloading ~ 30% Mobile Data Traffic and Improving User Experience

Share of iPhone data traffic

Source: ComScore Digital Omnivores, Oct. 2011

Share of iPad data traffic
The Great Disconnect: Scarcity Amidst Abundance

➢ FCC: “Looming spectrum crisis”
  o “Mobile data demand to grow 25 to 50 X within 5 years”
  o “the broadband spectrum deficit is likely to approach 300 MHz by 2014”

➢ Yet NSF studies of actual spectrum use show <20% beachfront spectrum used in even the most congested cities (NY, DC, Chicago).

➢ Challenge: Seamless, high-capacity mobile connectivity at affordable prices will require an enormous increase in overall capacity
Advantages of Building on TV Bands Database

- **No permanent assignments, no stranded users**
  - Any band can be listed – then de-listed
  - CSMAC: Prohibit single-frequency and unconnected (‘dumb’) devices on new shared and unlicensed bands

- Access to each band can be subject to unique access/operating conditions

- Preemption, shut down and priority access can protect primary operations

- Any ‘Tragedy of the Commons’ can be avoided
  - At any point, access can be limited or conditioned on micro-payments

- Enhanced features can be added (e.g., sensing)
Other Benefits of Extending TVDB to Govern Shared Access to Other Bands

- **A Platform to Enable Secondary Markets**
  - Geolocation database(s) can manage opportunistic access
  - Transparency, automation and standards can be leveraged to lower transaction costs for small-area and as-needed secondary market transactions

- **More capacity and efficient use spectrum**
  - Spectrum re-use and backhaul is most cost-effective at the edge of the network, closest to end user
  - Hybrid networks relying on low-power access to shared spectrum, small cells and self-provisioned backhaul will be most cost-effective and spectrum-efficient way to meet high-capacity and peak use

- **More Competition and Innovation**
  - Low barriers to entry
  - Indicators: ~ 2,000 WISPs and proliferation of unlicensed devices

- **An alternative to toothless use-it-or-lose-it**
General Approach: *Use it or Share it*

- **National Broadband Plan:**
  “The FCC should spur further development and deployment of opportunistic uses across more radio spectrum.” (p. 95)

- **PCAST:** Licenses are for exclusive *use ... not non-use*.

- **Under Communications Act,** unused capacity remains available to the public.

- **Proposal:** Identify and open the most underutilized and useful bands for opportunistic sharing on a secondary basis.

  - Subject to band-by-band conditions protecting incumbent uses from interference:
    - Transmit power limits
    - Geographic exclusion zones
    - Coordination with geolocation database (“connected devices”)
    - Sensing/DFS
    - Remote preemption/updating/disabling (“policy radios”)
Three Categories of Bands for Shared Access

1. Warehoused FCC Spectrum

2. Underutilized Federal Bands
   - ~ 1,000 MHz per PCAST

3. Fallow Licensed Bands (not built out)
12 bands identified and prioritized to consider for repurposing:

<table>
<thead>
<tr>
<th>Licensed non-federal exclusive use bands</th>
<th>Non-federal/federal shared use bands</th>
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<tbody>
<tr>
<td>1. 1755-1850 MHz</td>
<td>1. 1300-1370 MHz</td>
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<td>2. 1695-1710 MHz</td>
<td>2. 1675-1695 MHz</td>
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<tr>
<td>3. 406.1-420 MHz</td>
<td>3. 2700-2900 MHz</td>
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<tr>
<td>4. 1370-1390 MHz</td>
<td>4. 2900-3100 MHz</td>
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<td>5. 4200-4400 MHz</td>
<td>5. 3100-3500 MHz</td>
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<tr>
<td>6. 3500-3650 MHz</td>
<td>6. 2200-2290 MHz</td>
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