White Spaces Regulations and Standards

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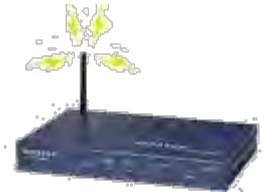
FCC to Open Unused TV Airwaves, Extending Wi-Fi's Possibilities

- Sep 23, 2010 The FCC reaffirmed a 2008 decision to open the broadcast airwaves
- Enables Wi-Fi networks with longer range
  - Microsoft reports achieving a mile of operating range on their Redmond, Wash., campus
- Broadcasters and wireless microphone operators expected to resume the law suit filed against the FCC in 2009 to stop new uses of the TV spectrum

Introducing TV White Spaces

- Spectrum under 3 GHz has significant unused capacity
  - Average occupancy over various locations studied is 5.2% and the maximum occupancy is 13.1% (in New York City)
  - Shared Spectrum Company, NSF funded measurements, http://www.sharedspectrum.com/measurements
- Only 10% of Americans receive broadcast TV
  - J. H. Snider and Max Vilimpoc, “Reclaiming the vast wasteland” http://vilimpoc.org/research/policy/Issue-Brief-12-Unlicensed-Sharing-of-Broadcast-Spectrum.pdf
- The economic potential for the TV white spaces was estimated at $100 billion
  - R. Thanki, “The economic value generated by current and future allocations of unlicensed spectrum,” http://www.ingeniousmedia.co.uk/websitefiles/Value_of_unlicensed_-_website_-_FINAL.pdf
- Modern technology allows effective sharing of sparsely used TV broadcast spectrum
- In 2004, the FCC started investigating the potential of allowing operation of unlicensed 2-way data communications in the TV broadcast VHF and UHF bands



TVBD
TV Band Device

History and Regulatory Landscape

- NPRM in May 2004
  - http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-04-113A1.pdf
- November 4, 2008 FCC approved Report & Order 08-260, allowing unlicensed use of TV band spectrum
  - http://hraunfoss.fcc.gov/edocs_public/attachmatch/DA-01-260A1.pdf
- February 17, 2009, the FCC released the final rules for “Unlicensed Operation in the TV Broadcast Bands”
  - http://edocket.access.gpo.gov/2009/pdf/E9-3279.pdf
- Ofcom (UK) is in the process of making this Digital Dividend band available
  - https://mentor.ieee.org/802.18/dcn/09/18-09-0059-00-0000-ofcom-update-on-the-digital-dividend.ppt
- ECC of CEPT in Europe is conducting consultation on the band
  - http://www.ero.dk/D9634A59-1F13-40D1-91E9-DAE6468ED66C?frames=no&
  - Requirements for operation of cognitive radio systems in the "white spaces" of the frequency band 470-790 MHz
  - Consultation closes 11/30/10
- China TV band regulations expected in 2015

ECC = Electronic Communications Committee
CEPT = European Conference on Postal and Telecommunications
NPRM = Notice of Proposed Rule Making

Frequency Allocation of TV Channels

	Channel #	Frequency Band	
Fixed TVBDs only	2-4	54-72 MHz	VHF
	5-6	76-88 MHz	
	7-13	174-216 MHz	
	14-20	470-512 MHz**	UHF
	21-51*	512-692 MHz	

*Channel 37 (608-614 MHz) is reserved for radio astronomy
**Shared with public safety
http://www.fcc.gov/mb/engineering/usallochrt.pdf

Transition from NTSC to ATSC (analog to digital TV) in June 12, 2009 freed up channels 52-69 (above 692 MHz)

NTSC = National Television System Committee
ATSC = Advanced Television Systems Committee

Unlicensed Bands and Services

Frequency range	Bandwidth	Band	Notes
433.05 – 434.79 MHz	1.74 MHz	ISM	Europe
420–450 MHz	30 MHz	Amateur	US
868-870 MHz	2 MHz	ISM	Europe
902–928 MHz	26 MHz	ISM-900	Region 2
2.4–2.5 GHz	100 MHz	ISM-2400	International allocations (see slides 7, 8 for details)
5.15–5.35 GHz	200 MHz	UNII-1,2	
5.47–5.725 GHz	255 MHz	UNII-2 ext.	
5.725–5.875 GHz	150 MHz	ISM-5800 UNII-3	
24–24.25 GHz	250 MHz	ISM	US, Europe
57-64 GHz 59-66 GHz	7 GHz	ISM	US Europe

TVB

Medical devices
Remote control

RFID and other unlicensed services

Smart meters, remote control, baby monitors, cordless phones

802.11b/g/n, Bluetooth
802.15.4 (Bluetooth, ZigBee), cordless phones

802.11a/n, cordless phones

Emerging 802.11ad
802.15.3c, ECMA-387
WirelessHD

Americas, including US and Canada; Australia, Israel

European analog of the ISM-900 band

ISM = industrial, scientific and medical
UNII = unlicensed national information infrastructure

Operation in TV Bands – Latest Rules

Access based on *geo-location & database* or *spectrum sensing*

Fixed

For fixed TVBDs max output power < 4 Watts EIRP

Must access a TV bands database over the Internet to determine channel availability

Personal /portable

For PP TVBDs max output power < 100 mW EIRP on non-adjacent channels and < 40 mW EIRP on adjacent channels

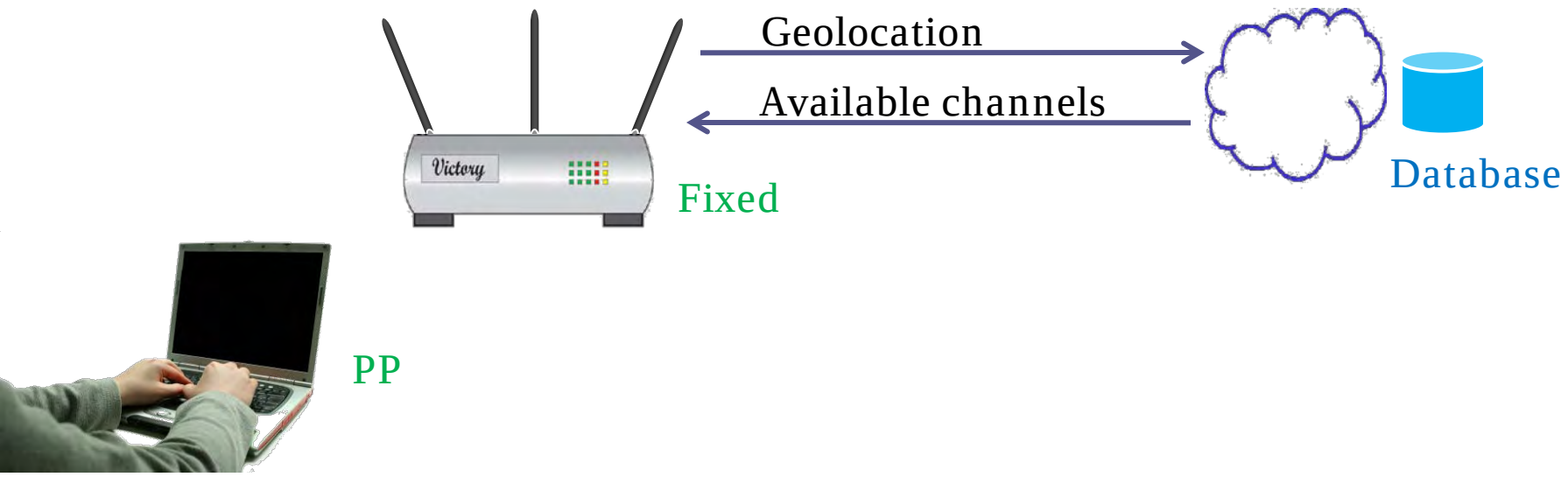
Mode I: obtain a list of available channels from a master device

Mode II: incorporate geo-location capability

PP = personal/portable

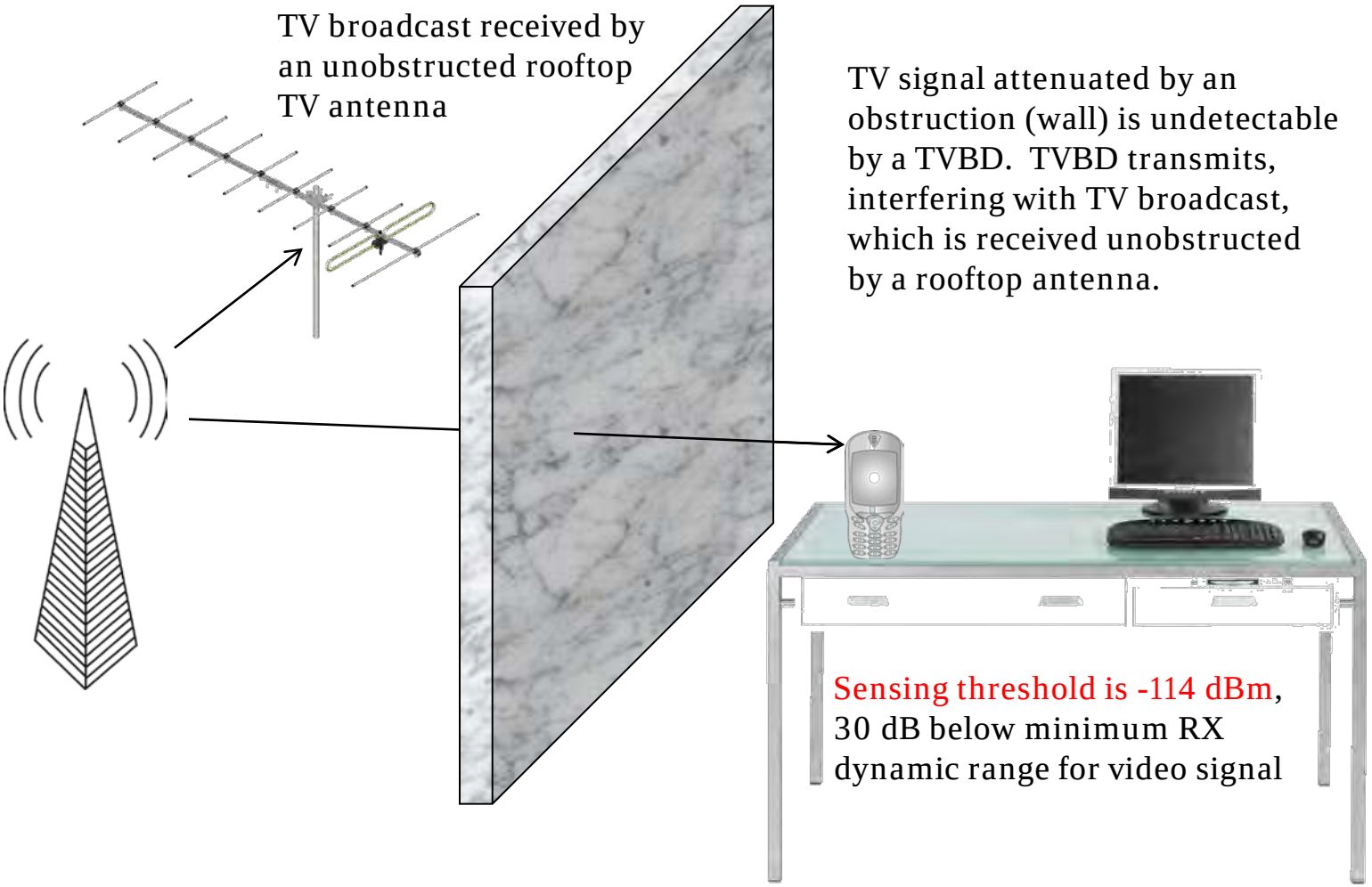
Database

- Fixed TVBDs require geolocation capability and Internet access to a database of protected radio services.
- *White Spaces Database Group* was started by Google and other companies to create and standardize the database.



Spectrum Sensing

TV broadcast received by an unobstructed rooftop TV antenna

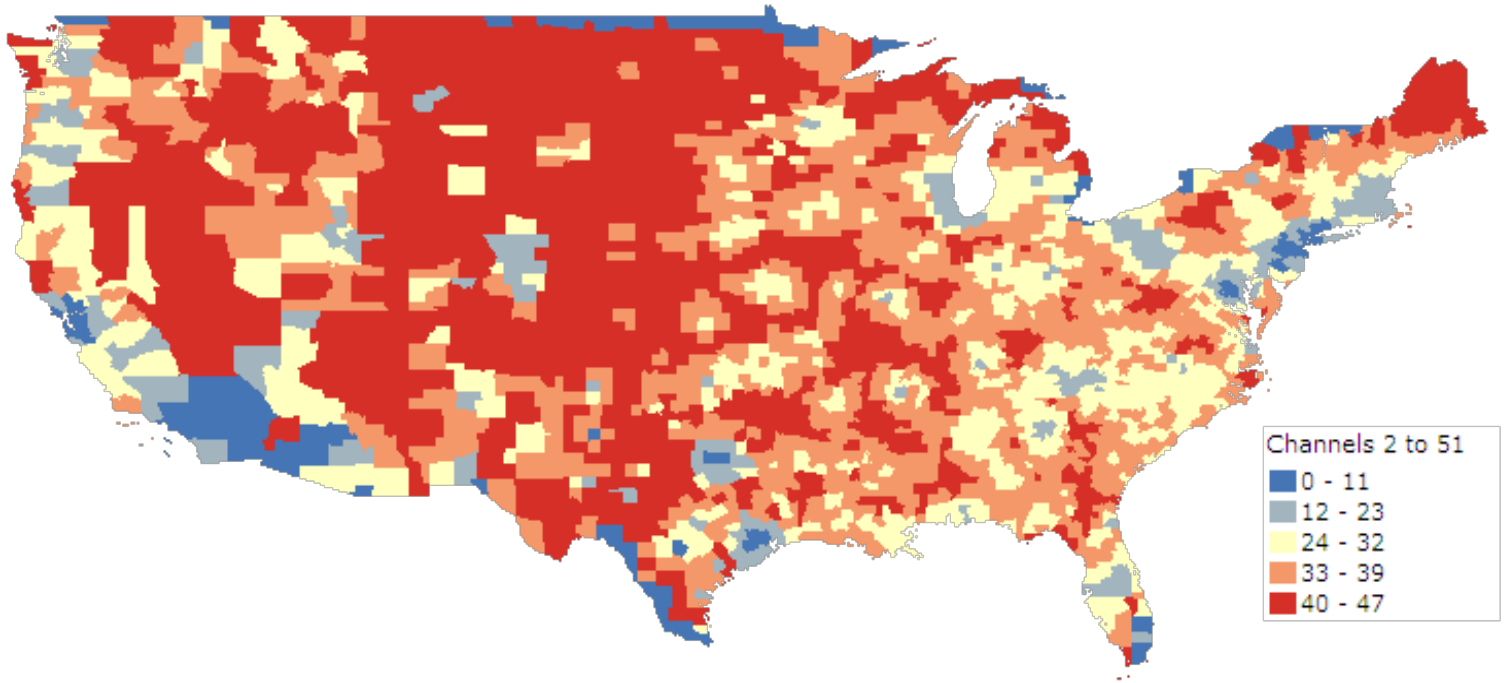


TV signal attenuated by an obstruction (wall) is undetectable by a TVBD. TVBD transmits, interfering with TV broadcast, which is received unobstructed by a rooftop antenna.

Sensing threshold is -114 dBm, 30 dB below minimum RX dynamic range for video signal

Taking Advantage of TV White Spaces

- Channel availability based on the geolocation query of TV band internet database



Source: Rick Tornado, Spectrum Bridge

IEEE TV Band Related Standards

- **802.11af** – formed in January 2010 to adapt 802.11 to TV band operation
- **802.16h** – originally organized to adapt 802.16 to the 3650-3700 MHz contention band now working on TV band operation of 802.16
- **802.22** – cognitive radio approach
  - Regional Area Networks group that guided the FCC in the recent TV band regulations
  - Uses spectrum sensing and location information to determine whether given transmit frequencies and power levels will cause harmful interference to licensed services.
- **802.19** TAG – defines coexistence among dissimilar networks that will operate in the TV band
- **SCC 41** – defines layers above the MAC and PHY for dynamic spectrum access networks

TAG = technical advisory group

Contention Band

- March 2005 FCC offered 50 MHz 3650 to 3700 MHz for *contention-based protocol*
- 802.11y and 802.16h are expected to share this band
- 21st century regulation geared for digital communications
  - multiple services to share the band in an orderly way

- **300 Million licenses one for every person or company**
- **$300 per license for 10 years**
- **Registered stations (base stations): 1 W/MHz, ~15 km**
- **Unregistered stations (handsets, laptops): 40 mW/MHz, 1-1.5 km**

802.11af

- Re-band the popular 802.11 systems; capitalize on work already done for 802.11y
  - Use 5, 10, 20 and 40 MHz wide channels
  - FCC EIRP: 4 W, 100 mW, 50 mW
- Possible deployment scenarios
  - Indoor (< 100 m): like present WLAN
  - Outdoor (< 5 km): comparable to the range of typical urban model
- Database is considered out of scope of 802.11af

Ecma and CogNeA TV Band Standard

- Ecma International TC48-TG1 is developing PHY-MAC and coexistence protocols for wireless networks in the TV band http://www.ecma-international.org/memento/TC48-TG1.htm
- Sponsor Organization: Ecma International (http://www.ecma-international.org) and CogNeA (http://www.cognea.org)
- CogNeA and Ecma TC48-TG1 standard
  - CogNeA is an industry alliance formed in 2008 to develop a specification for white spaces.
  - In March 2009 the draft/early specification developed by CogNeA was transferred to the Technical Committee 48 – Task Group 1 (TC48-TG1) within Ecma-International
  - http://www.ecma-international.org/publications/files/drafts/tc48-tg1-2009-132.pdf

CogNeA = Cognitive Networking Alliance

Future of TV Band Use

- Dynamic spectrum market with the database access capability
  - Buy spectrum for a slice of time/space/band
- Protocol? Contention-based Wi-Fi?
  - Currently no plans to regulate by the FCC
- Technology must evolve to make flexible use of available channels up to 6 GHz
  - RF front end technology still not ready for this

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  - http://www.octoscope.com/English/Resources/Articles.html

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