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Operational challenges for emerging cognitive radio technologies

Wireless Devices Utilizing TV White Spaces

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Presentation outline

- Some definitions
- Motivation to use white spaces
- Challenges in using white spaces
- Current standardization and regulation activities
- Finnish activities
- Q&A

What is cognitive radio?

- ITU-R Report SM.2152, “Definitions of Software Defined Radio (SDR) and Cognitive Radio System (CRS)”, http://www.itu.int/pub/R-REP-SM.2152:

  “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 state; 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.”
- Term cognitive radio first used Joseph Mitola III 1999. Mitola envisioned wireless device, which would emulate human cognition cycle – observe, orient, plan, decide/learn, and act.

What is white space?

- Locations where spectrum allocated for some wireless communication system is unutilized appear as white areas in system coverage maps.
- Therefore, they are referred to as *White spaces*.
  - Another names are spectral holes or spectral gaps
- TV white space (TVWS) is the unused spectrum on TV broadcasting frequencies (UHF and VHF bands) in an arbitrary location. TV White Spaces are created especially by efficient spectrum utilization of the digital broadcasting.

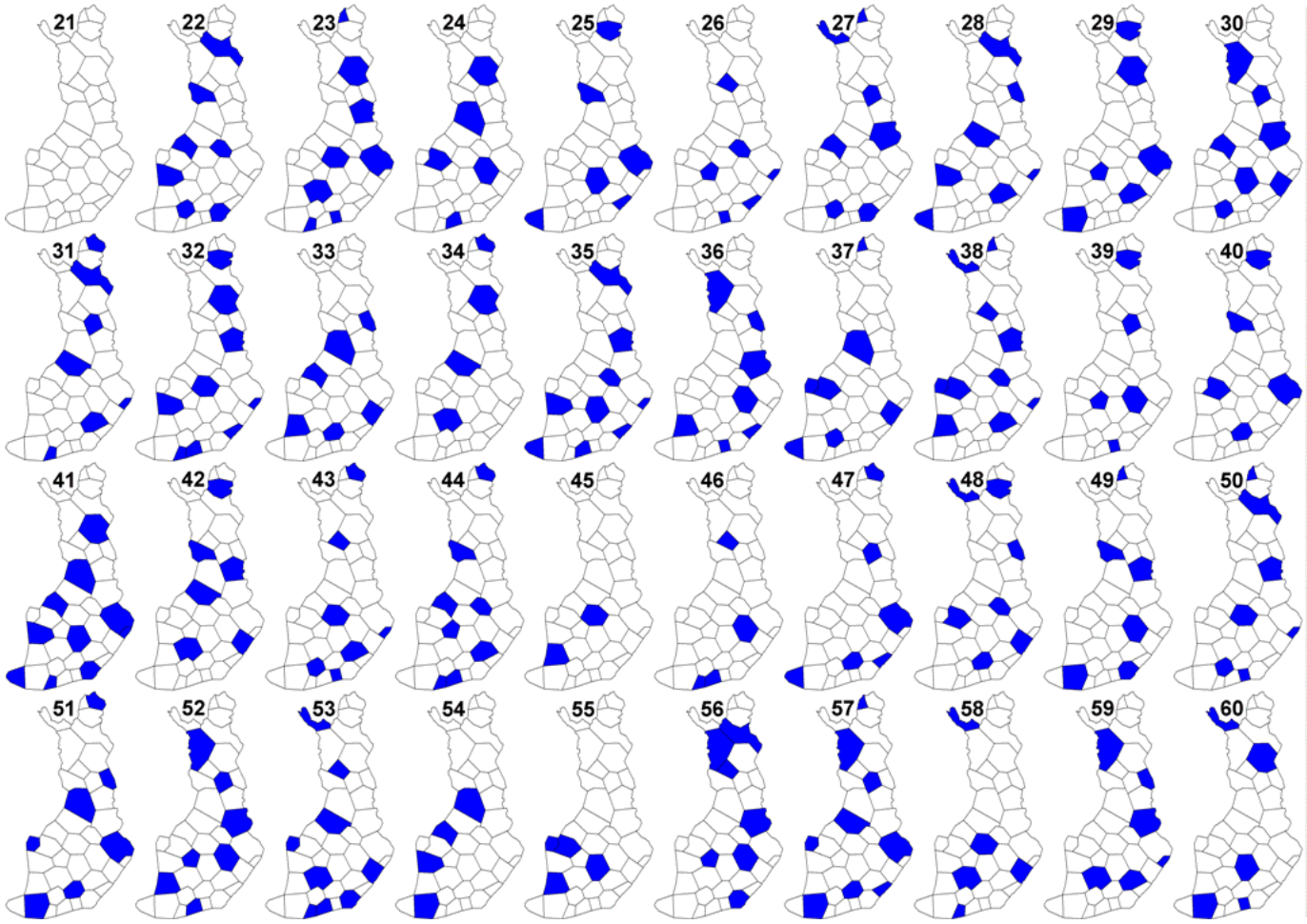
Why to use white spaces?

- Driving force is due to spectrum shortage.
- The huge growth of mobile data utilization has showed that current spectrum allocations for cellular or Wi-Fi networks are inadequate.
- Traditionally, frequencies are strictly regulated to guarantee that wireless communication systems do not cause interference to each other.
  - Frequency bands have been also allocated for unlicensed operation. For example, ISM band at 2.4 GHz frequency is used by WLAN and Bluetooth transmissions among other systems
- Drawback of strict regulation is that the spectrum utilization is not optimal. Depending on wireless system there can be substantial temporal and geographical differences how spectral resources are utilized.

Why to concentrate on TV white spaces?

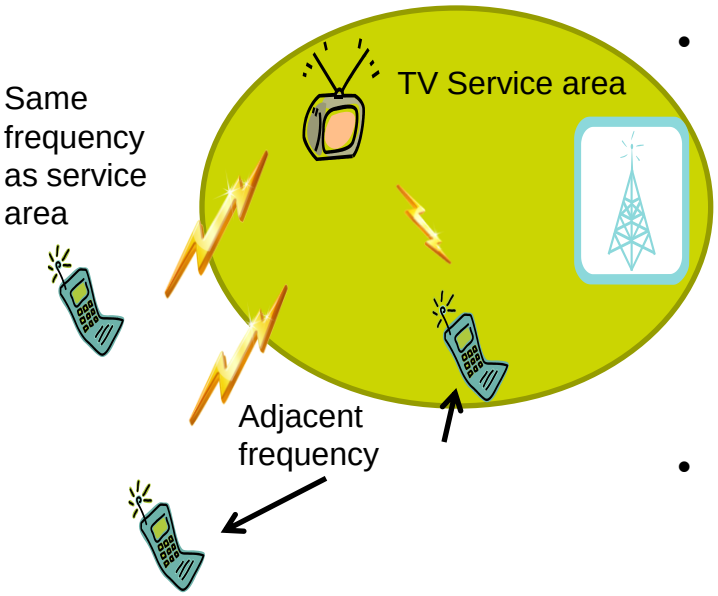
- The transition from analog TV transmissions to digital TV frees up large amounts of frequencies in VHF and UHF bands.
- Frequencies in VHF and UHF bands are very attractive from network point-of-view.
  - Possible to cover large areas with small amount of base stations, which lowers network building costs.
- TV signal quite stable and easy to predict, which helps in interference control
- Drawbacks:
  - Wireless microphones use also the same frequencies
  - Antenna size grows in lower frequencies

TV White spaces in Finland (470-790 MHz)



Kanava	Taajuus (MHz)
21	470–478
22	478–486
23	486–494
24	494–502
25	502–510
26	510–518
27	518–526
28	526–534
29	534–542
30	542–550
31	550–558
32	558–566
33	566–574
34	574–582
35	582–590
36	590–598
37	598–606
38	606–614
39	614–622
40	622–630
41	630–638
42	638–656
43	646–654
44	654–662
45	662–670
46	670–678
47	678–686
48	686–694
49	694–702
50	702–710
51	710–718
52	718–726
53	726–734
54	734–742
55	742–750
56	750–758
57	758–766
58	766–774
59	774–782
60	782–790

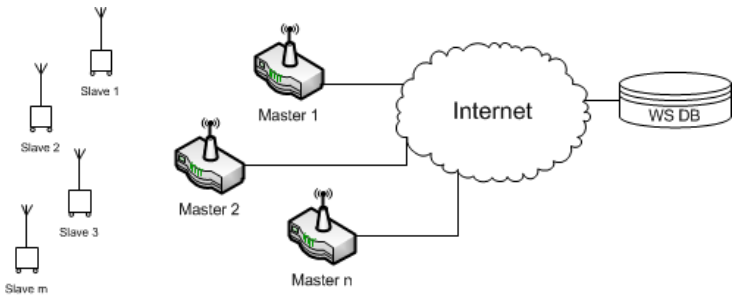
So far so good, but..



- How to provide enablers for commercial operation of wireless devices in TV white space?
- Key issue: TRUST
- Obstacles in deployment of TVWS systems
  - Regulatory bodies uncertain how to protect primary systems (TV, radio microphones)
  - Also, many operators opposing
    - Systems seen as additional interference
    - Maybe fear for losing profit with changed value networks?
- Our goal is to find out how to build trust

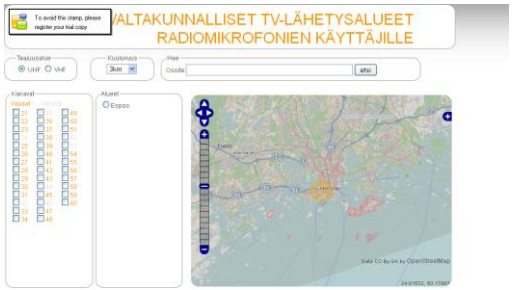
Possible methods for white space access

- Sensing
  - Difficult to perform (wide frequency range, hidden node problem, …)
- Beacon signal
  - Potential extra interference, requires dedicated frequencies
- **<u>Geolocation database</u>**
  - Devices query available frequencies from database located in Internet
  - Must guarantee negligible interference to incumbents
  - Must guarantee information security



Some white space databases

- Spectrumbridge – Show my white space
  - http://whitespaces.spectrumbridge.com/whitespaces/home.aspx
  - Also iPhone, iPad application available
- Microsoft Research WhiteFiService
  - http://whitespaces.msresearch.us/
- Fairspectrum
  - http://www.fairspectrum.com
  - http://www.radiomikrofonit.fi/test/
    - Soon the be obsolete URL



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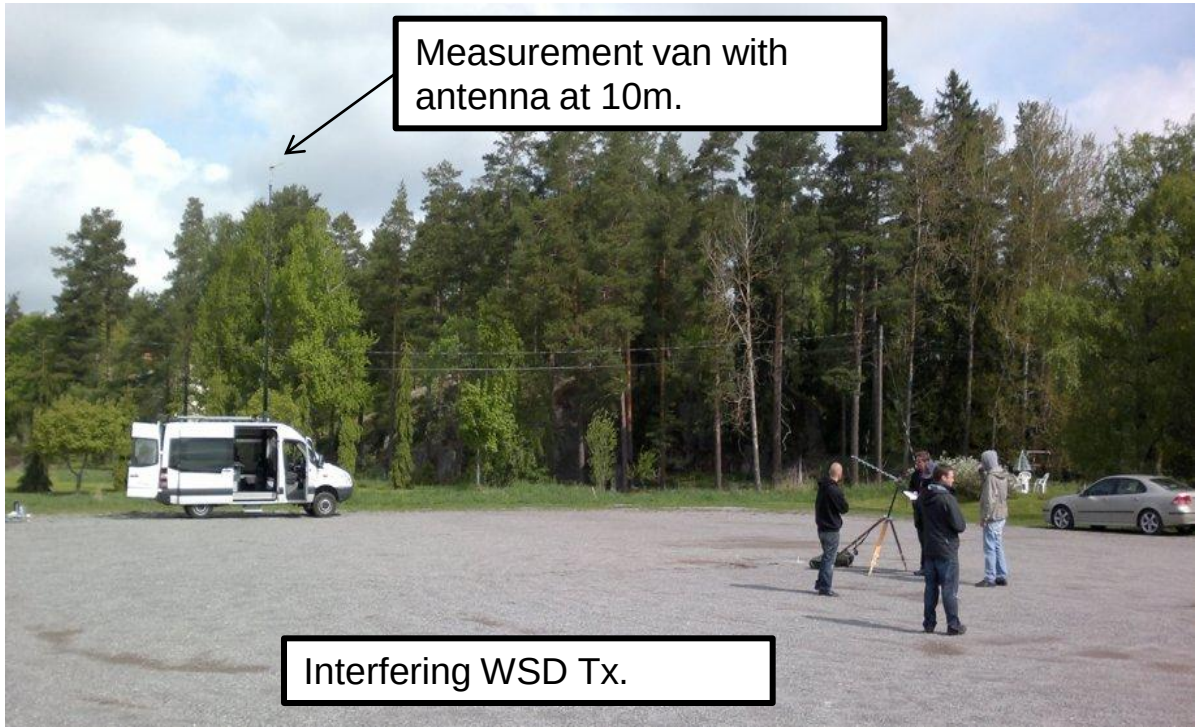
Interference challenge

- How to set geographical ares and power limits for white space devices?
- A lot of efforts going on in EU, Asia, USA
- For example in Turku, Finland:

DVB-T test transmission at 610 MHz from Pääskyvuori transmitter.



Security challenges

- Geo-location database is accessed through public Internet.
- Compromised information security could block TV transmissions in addition to white space network. Thus, at least following issues has to be considered
  - Confidentiality
  - Mutual authentication
  - Integrity of database content
  - Reliability of database i.e. service continuity
- Security is ultimately the responsibility of the database administrator.

Current standardization activities include

- IEEE 802.22
  - Wireless broadband for rural areas
  - ”Super Wi-Fi” or ”Wi-Fi on steroids”
- IEEE 802.11af
  - Wi-Fi extension to TVWS
- IEEE 802.16h
  - WiMAX extension to TVWS
- IEEE 802.19.1
  - Co-existence of several white space systems
- IETF PAWS
  - Protocol to acces white space
  - Device - database communication protocol

Current regulatory activities

- FCC (USA)
  - Ten database operators are selected (incl. Google and Microsoft)
  - First pre-commercial pilot currently underway
- Ofcom (UK)
  - Decision September 2011 to start commercial operation ”as soon as possible”
- CEPT SE43 (EU)
  - Working for harmonized approach
  - Focus on interference issues
- Industry Canada
  - Published (August 2011): Consultation on a Policy and Technical Framework for the Use of Non-Broadcasting Applications in the Television Broadcasting Bands Below 698 MHz
- FICORA (Finland)
  - Test licenses granted

Status in Finland

- Tekes technology program *Trial – Environment for Cognitive Radio and Networks 2011–2014*
  - http://www.tekes.fi/programmes/trial
- “The aim of the programme is to transform Finland into a globally attractive cluster of expertise and unique trial environment for cognitive radio and networks.”
- Tekes – *the Finnish Funding Agency for Technology and Innovation* is the main public funding organisation for research, development and innovation in Finland.
- Estimated volume of Trial program is 32 M€ from which Tekes funding is approximately 14 M€
  - Currently running 3 research projects and 8 industry projects

WISE (White space test environment for broadcast frequencies)

- Work based on Turku test network and Fairspectrum geolocation database
- Database algorithm development
- Interference measurements
- Capacity simulations
- Information security architecture
- Regular contributions to standardization and regulation

http://wise.turkuamk.fi/

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More information:
http://www.tekes.fi/programmes/trial
http://wise.turkuamk.fi/

THANK YOU!