

Project: IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)

Submission Title: WPAN Applications Operating in TV White Space

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Re: [802.15.SG 4TV]

Abstract: WPAN Applications Operating in TV White Space

Purpose: To discuss WPAN applications operating in TV white space

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Outline

- The goal of this document is to help the SG4TV to determine next steps by presenting known service models and possible WPAN applications operating in TV white space
- This document includes
 - TV white space introduction
 - TV white space service model
 - WPAN Applications operating in TV white space
 - Possible scope and purpose for PAR

TV White Space Introduction

TV White Space

- TV White space (TVWS)
 - Unused radio spectrum which has either never been used, or is becoming free as a result of technical changes
- TVWS Characteristics
 - TVWS network operates in VHF/UHF band.
 - The center frequencies are fixed and specified for each TV channel.
 - The band may not be continuous.
 - Bandwidth of each TV channel is 6MHz in US and 7MHz or 8MHz in other area.

TV White Space

- Comparison of TVWS band with 2.4GHz and 5GHz
 - Path loss → smaller
 - Number of multiple paths → more
 - Delay spread → bigger
 - Coherent bandwidth → smaller
 - Doppler frequency → lower
 - Coherent time → larger

TV White Space

- TVWS bands are attractive for the following reasons:
 - The availability of a large amount of spectrum that can be used to provide connectivity
 - Propagation qualities that provide for Line of Sight (LOS), Near Line of Sight (nLOS) and Non Line of Sight (NLOS) performance
 - Larger coverage areas due to excellent propagation characteristics that allow signals to reach farther and penetrate walls and other structures

FCC Decision on TVWS

- On **November 4, 2008**, the FCC permitted both fixed and personal/portable unlicensed devices to operate in the TV bands.

| CH | Frequency(MHz) | Target device |
|-------|----------------|---|
| 2 | 54 - 60 | Fixed device |
| 5-6 | 76 - 88 | Fixed device |
| 7-13 | 174 - 216 | Fixed device |
| 14-20 | 470 - 512 | Fixed device |
| 21-36 | 512 - 608 | Fixed device , personal/portable device |
| 38-51 | 614 - 698 | Fixed device , personal/portable device |

FCC Decision on TVWS

- On **September 23, 2010** the FCC released a Memorandum Opinion and Order that determined the final rules for the use of white space for unlicensed wireless devices.
- **The new rules removed mandatory sensing requirements** which greatly facilitates the use of the spectrum with geolocation based channel allocation.
- The final rules adopt a proposal from the White Spaces Coalition for very strict emission rules that prevent the direct use of other TV band device (TVBD).

Simple TV White Space Operation

- 1. On-air TV Transmitters and other protected users are listed in FCC Database.
- 2. TVWS Transmitter uses geolocation and reads FCC database to identify the unused channels that are available at its location.
- 3. TVWS system protects incumbent channel by communicating on an available channel.

FCC Regulations

- Protection criteria for incumbent services
 - Fixed and Mode II personal/portable devices operating with power levels **greater than 40mW** must operate **outside** the protected contours of both **co-channel and adjacent channel** TV stations at a sufficient separation distance.
 - At least three continuous TVWS bands should be available.
 - Personal/portable device operating with power levels of **40mW or less** are permitted to operate **within** the protected contours of **adjacent channel** TV stations due to lower risk of causing harmful interference at that power level.

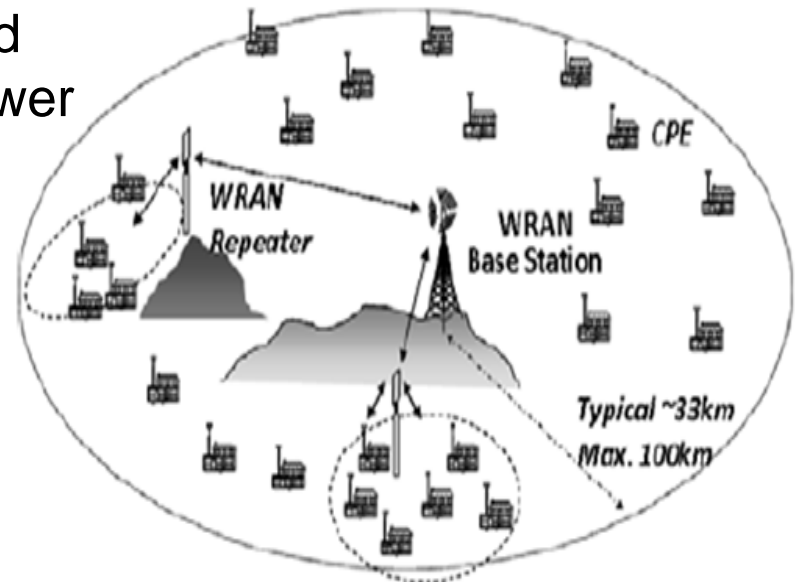
Activities related with TVWS

- IEEE 802.22 - WRAN
- IEEE 802.11af - TVWS WiFi
- IEEE 802.16h-2010 - Unlicensed WiMAX
- IEEE 802.19.1 - Interoperability
- ECMA TC-48 TG1
- White Spaces Coalition
- IEEE 802.15: SG4TV ??

TV White Space Service Model

TV White Space Service Model

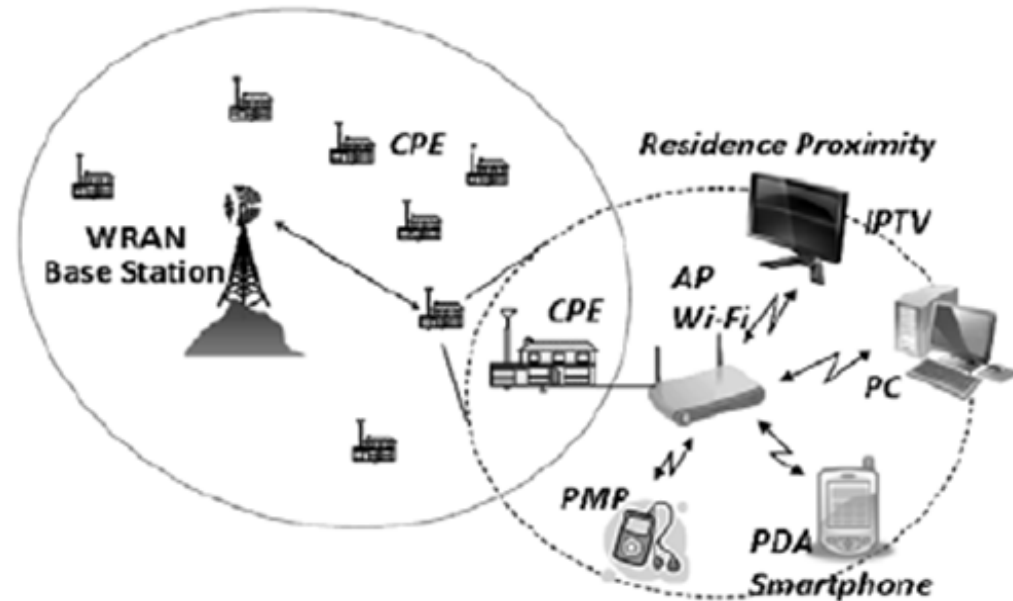
- Fixed-to-fixed Model: IEEE 802.22 WRAN
 - Service model to enable broadband wireless access in rural areas, farms and suburbs
 - Wireless connection between fixed WRAN BS and fixed CPE with power level of 4W EIRP
 - Protection of incumbent user
 - Fixed devices achieve the available channel information from the Geolocation database using fixed location



CPE: Customer premises equipment

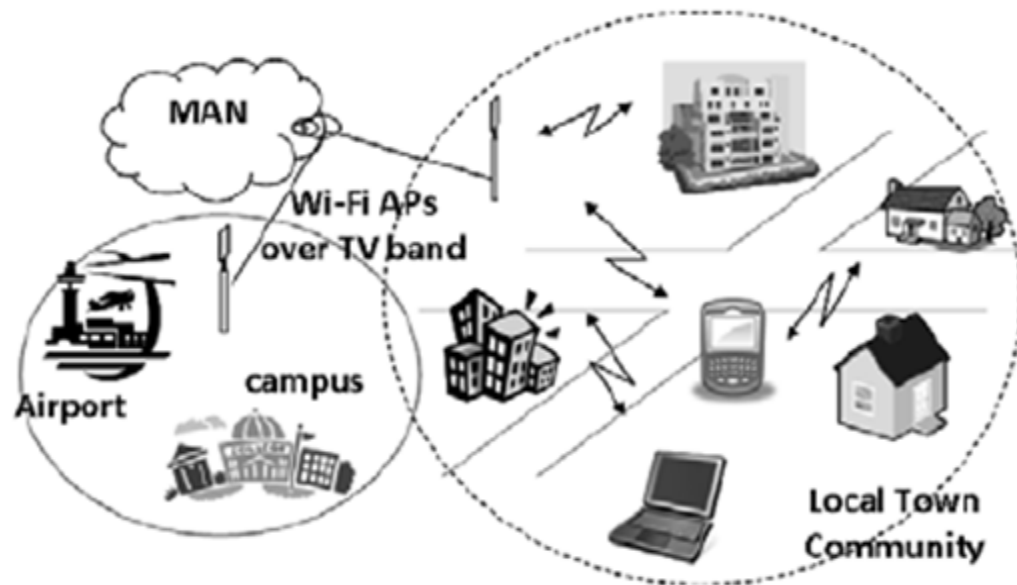
TV White Space Service Model

- Fixed-to-Fixed Ad-hoc Extended Model
 - In addition to WRAN model, in-home devices such as PC and IPTV can be connected to fixed CPE with interface of Wi-Fi AP.
 - Transmission power of personal/portable device
 - Outside adjacent channel: Max.100mW
 - Outside co-channel: Max. 40mW
 - Protection for incumbent users
 - Potable devices use the same channel with the fixed CPE



TV White Space Service Model

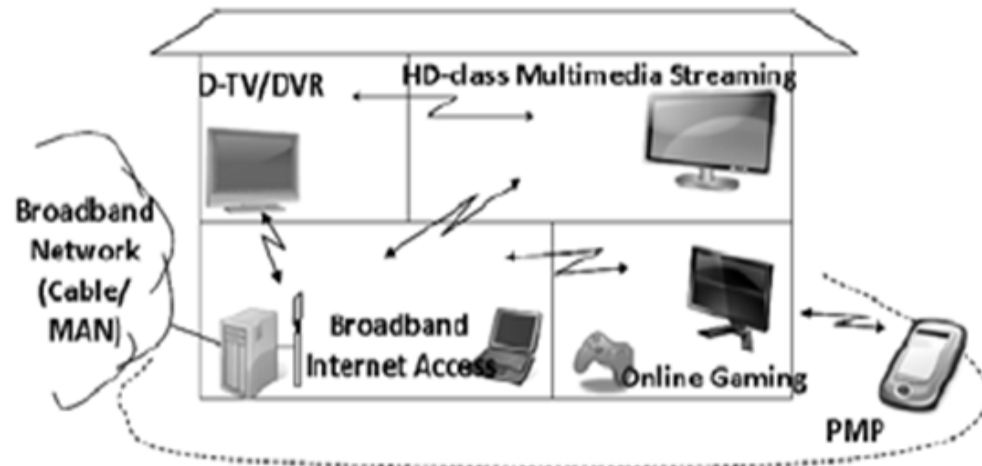
- Fixed-to-Fixed Public Access Point Model
 - Wi-Fi 2.0: Nationwide Wi-Fi networks
 - Using the same Wi-Fi MAC over newly developed TVWS PHY, the conventional IP-based services can be directly deployed
 - Fixed CPE: used as AP In the public area
 - # of available TV channels in metropolitan area might be small (1~2 channels)
 - TX Power: Max. 40mW
 - Wi-Fi Coverage is limited



TV White Space Service Model

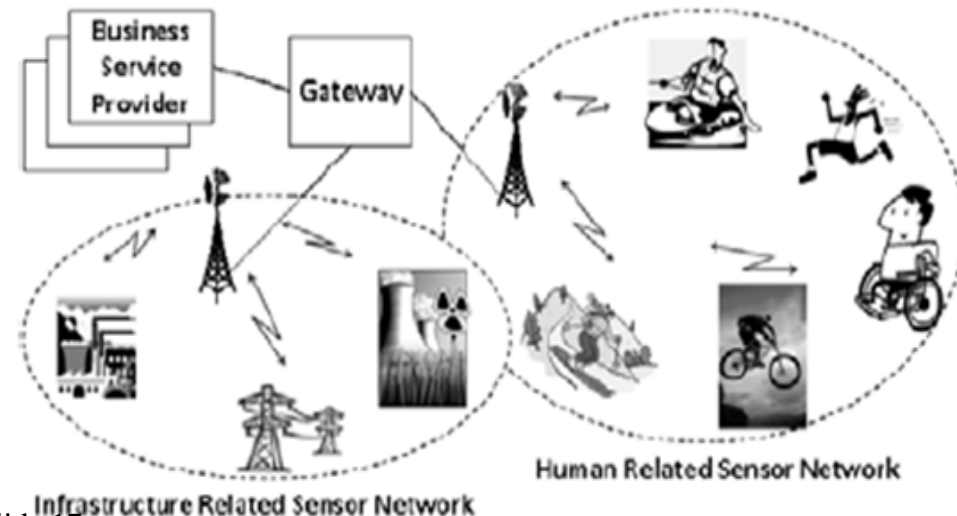
- In-house Multimedia Streaming Model

- Triple play service: telephone/internet/cableTV
- Conventional wireless solution (WLAN)
 - Penetration loss is too high (floor-to-floor or room-to-room)
- Cable based wired solution
 - High installation cost
- Standardization
 - Wireless solution based on TVWS channel
 - ECMA TC-38 TG1



TV White Space Service Model

- **Wireless Sensor Network Model**
 - Wireless sensor network operating in TVWS
 - Extended coverage & low-cost deployment
 - Robust & secure connection
 - Applications
 - Infrastructure related sensor network
 - Human related sensor network
 - Wireless Medical Telemetry Service (WMTS) is currently available in CH37
 - Remote monitoring and control of Life-critical equipments (e.g. pacemaker, drug pump)



Demonstration Project

- A number of TV bands device applications are already operating on an experimental basis
 - Wilmington (North Carolina): “Smart City” applications, including public “hot spots,” low-cost broadband to a low-income housing development, and water level and water purity sensors.
 - Claudville (Virginia): broadband access to a rural elementary school, as well as to consumers in their homes, and newly established public hot spots.
 - Plumas County (California): “Smart Grid” trial for electricity network, which allows the electric cooperative to manage the electrical system, obtain data from substation, and manage power flow.

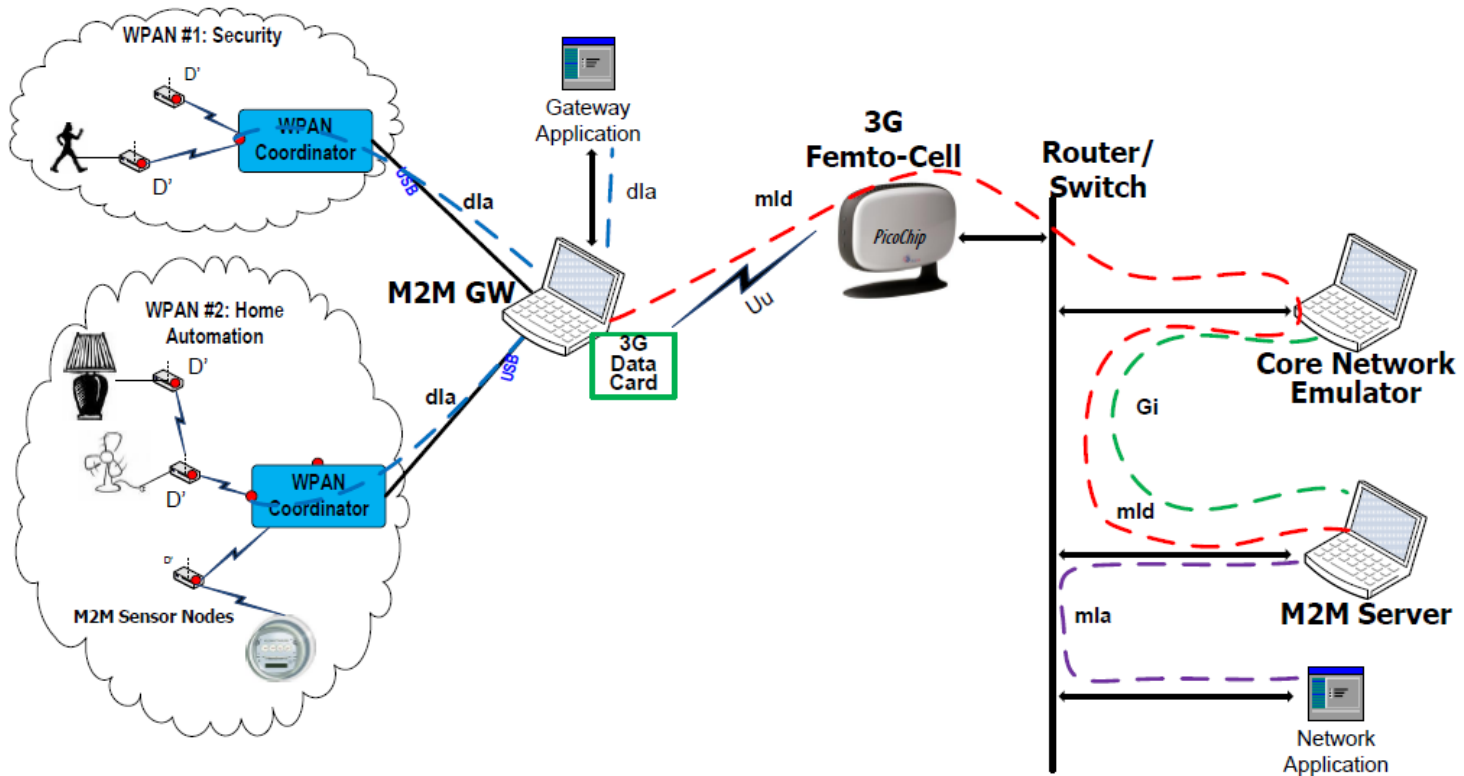
WPAN Applications operating in TVWS

WPAN Applications

- In accordance with wireless sensor network model, any WPAN applications can operate in TV white space.
 - Wireless sensor network
 - Smart utility network
 - Home network
 - Surveillance, control and monitoring network
 - Infrastructure monitoring network
 - Local Network in Machine to Machine (M2M) Scenario
 - ...

WPAN Applications

- WPAN usage in M2M system



Extension of WPAN to TVWS

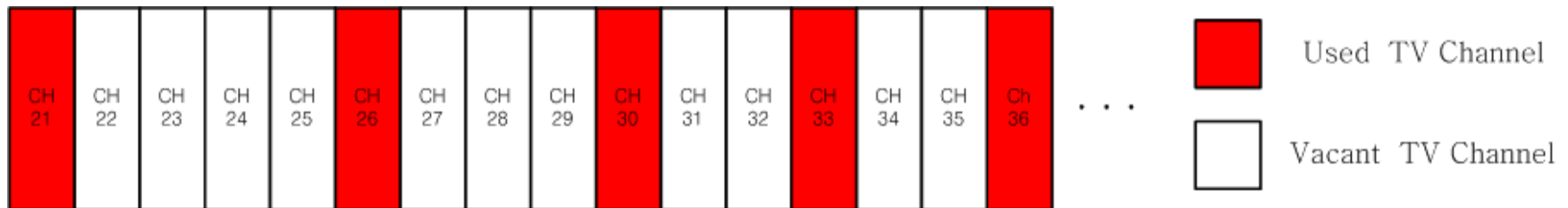
- Why is the extension of WPAN to TVWS required?
 - Scalable data rate on dynamic request basis
 - Additional bandwidth over crowded WPAN band due to increasing personal devices
 - Securer communication to WPAN
 - Low power and Power-efficient WPAN devices
 - Cost-effective WPAN deployment and management
 - Extended coverage
 - Enabling the effective use of TV white space
- Unlike WLAN, WPAN in TVWS can allow small, power-efficient, inexpensive solutions to be implemented for a wide range of devices

Effective Use of TV White Space Channels

- According to FCC regulation, personal/portable device operating with power level 40mW or less are permitted to operate in adjacent channel
 - Low power class only: WPAN devices
- Fixed and personal/portable devices with high transmission power must avoid co-channel and first-adjacent channels.
 - All power classes: WRAN or WLAN or WPAN devices
- Although WRAN and WLAN can easily fail to operate in scarce TVWS due to regulation, WPAN still have opportunity to operate in TVWS due to lower risk of causing harmful interference at the low power level.

Example of TV Channel Allocation

- WRAN and WLAN can use CH23, 24 and 28.
- WPAN can use CH22, 25, 27, 29, 31, 32, 34, 35, as well as 23, 24, 28.



Possible Scope and Purpose for PAR

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- **Scope:** An amendment that defines modifications to both the 802.15.4 physical layers (PHY) and the 802.15.4 Medium Access Control Layer (MAC), to meet the legal requirements for channel access and coexistence in the TV White Space
- **Purpose:** The purpose of this amendment is to allow 802.15.4 wireless networks to be used in the TV white space

References

- [1] IEEE802-sg-whitespace-09-0007-07-0000 “ECSG ADHOC USE CASE SLIDE DECK,” Jan. 2009
- [2] 11-10-0261-02-00af, March 2010
- [3] FCC Second Memorandum and Order, Sept., 2010
- [4] TV whitespace service model in the US, 2009
- [5] Analyzing the new TV white space rules, 2010