Spectrum Sensing with USRP and GNURadio

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Mobile Computing

Topics Discused

- 1. Motivation: Software Defined Radio and Cognitive Radio
- 2. Experimental Setup: Spectrum Sensing on CSU Wireless Network (802.11a/g, 2.4 GHz)
- 3. Results
- 4. Implications for 'Smart Grid'

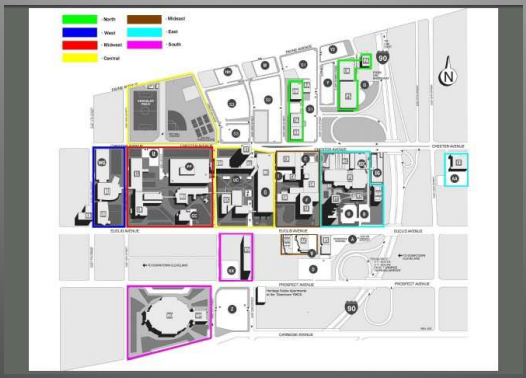
1.Intro: "Cognitive Radio"

- "Intelligent" radios that are adapted to sense spectrum holes and transmit data at those under-utilized frequencies
- Reconfigurability : using software-defined radio, the 'cognitive radio' can change its operating parameters: ***transmit-power,*** carrier ***frequency and modulation strategy***
- ***First Task: sense spectrum usage, availability***

1. Intro: Unlicensed Radio Spectrum

- Unlicensed spectrum:
- 902 Mhz – 928 Mhz cordless phones, baby monitors, Wireless LANS
- ***2.4 Ghz – 2.4835 Ghz 802.11***, Bluetooth, Microwave oven
- 5.725 Ghz – 5.785 Ghz unused

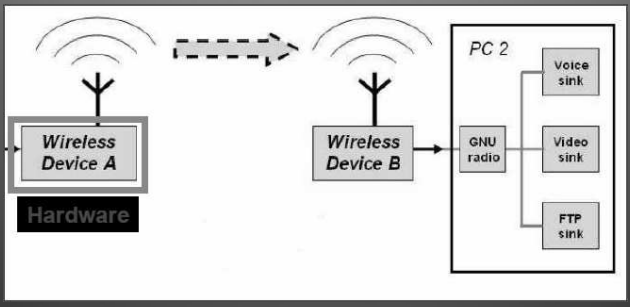
2. Experiment: CSU Wireless System Coverage



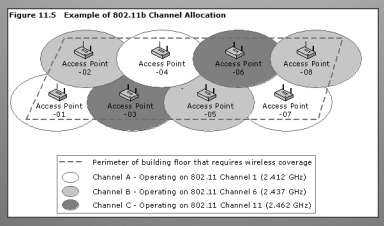
2.4 GHz band sensing in different CSU buildings (coverage areas), different floors, positions in buildings

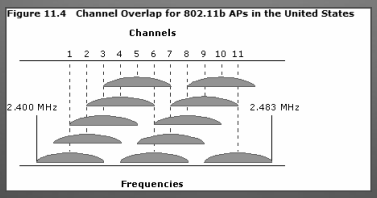
2. Gnu Radio as a Spectrum Sensing Device

- Usrp_spectrum_sense.py use with RFX2400 daughterboard to sense 2.4 GHz frequency range coverage
- "Wireless Device B" = USRP + RFX2400;
- "Wireless Device A" = CSU Transmission System



2. 802.11b coverage in a building





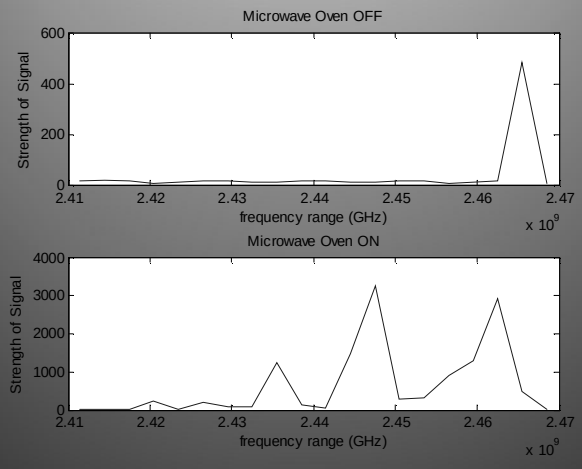
2. 802.11 Spectrum Channels

Channel	Lower Frequency	Central Frequency	Upper frequency
1	2.401	2.412	2.423
2	2.406	2.417	2.428
3	2.411	2.422	2.433
4	2.416	2.427	2.438
5	2.421	2.432	2.443
6	2.426	2.437	2.448
7	2.431	2.442	2.453
8	2.436	2.447	2.458
9	2.441	2.452	2.463
10	2.446	2.457	2.468
11	2.451	2.462	2.473

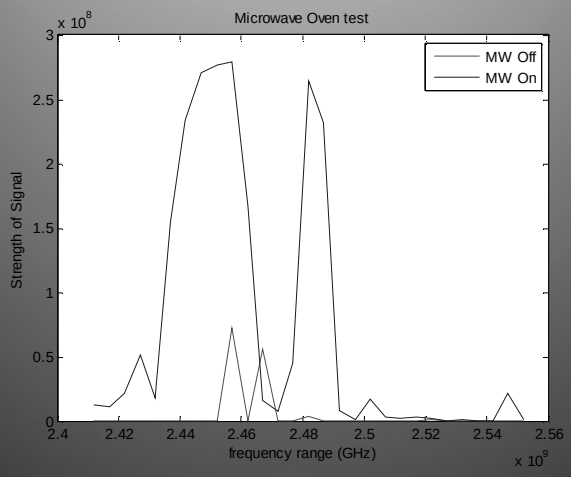
3. Results: Spectrum Sense Points

- (test on Microwave oven at home)
- Library, Main Classroom (computer center), Stillwell Hall, Rec Center
- Test for channel usage at each of 11 subchannels of 2.4 GHz band (2.412 GHz – 2.462 GHz)
- Use usrp_spectrum_sense.py function

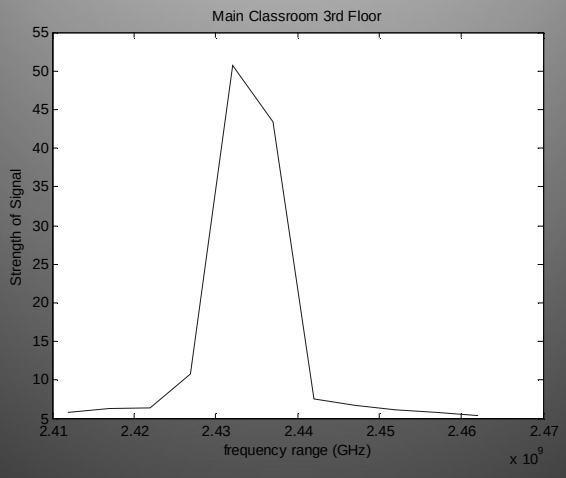
3. Test: Microwave Oven (test)



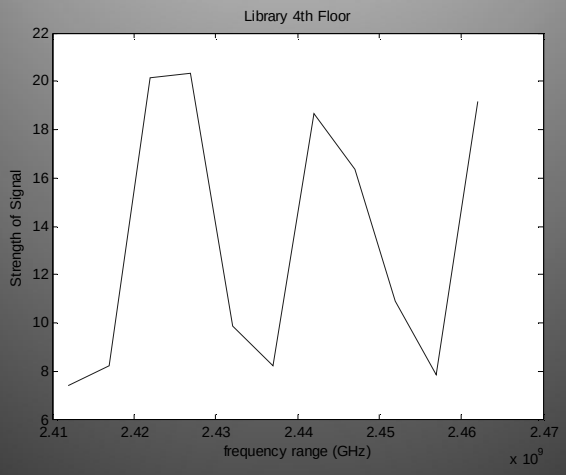
3. Test Microwave Oven



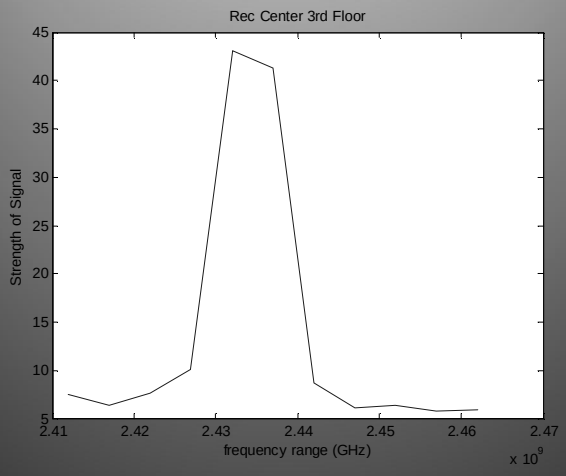
3. MC – Computer Center



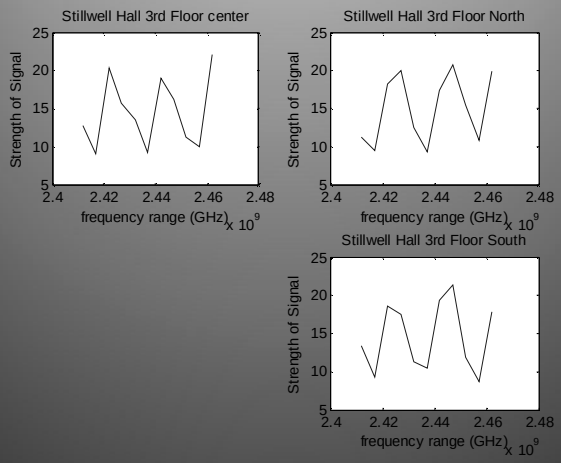
3. Library 4th Floor



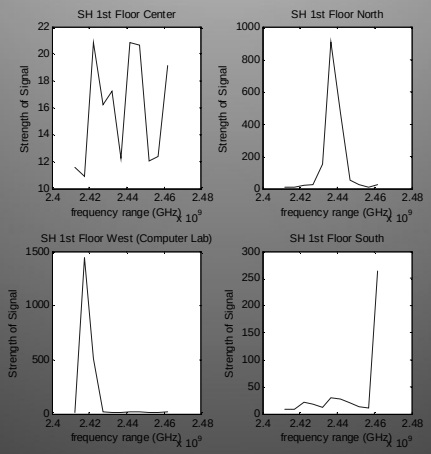
3. Rec Center



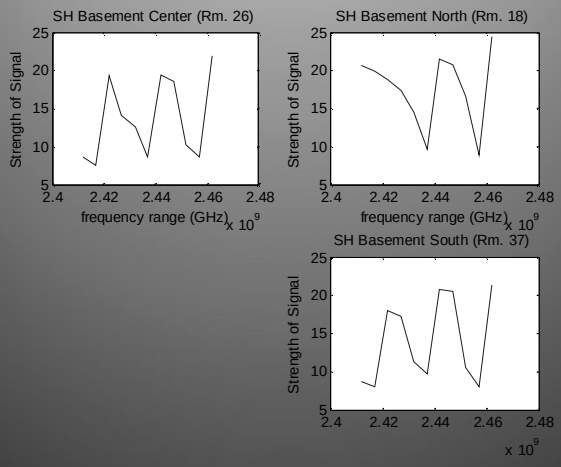
3. Stillwell Hall 3rd Floor



3. SH 1st Floor



3. SH Basement



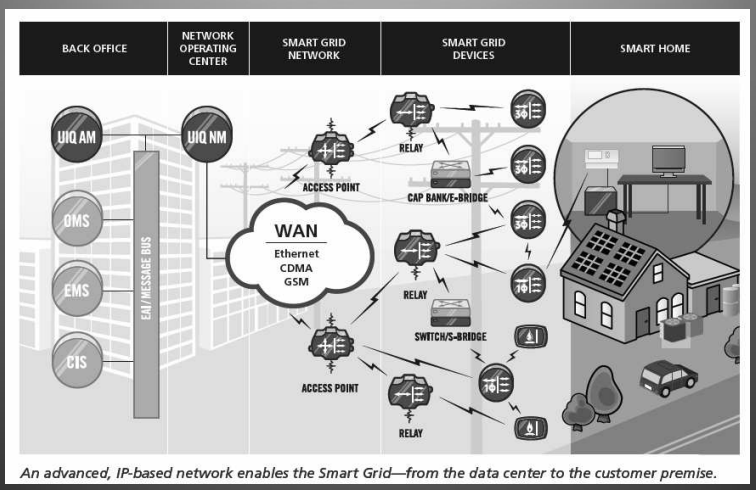
3. Results Summary

- Distinct Channels observed at various locations
- Channel Utilization over time appears constant

4. Application / Extension: Smart Grid

- A "Smart grid system" is any ***two-way communications system*** and associated equipment and software, including equipment installed on the electrical delivery system and on the premises of retail end-use customers, that utilizes the electrical delivery system to ***provide real-time monitoring, diagnostic, and control information…***

4. Smart Grid Illustration



An advanced, IP-based network enables the Smart Grid—from the data center to the customer premise.

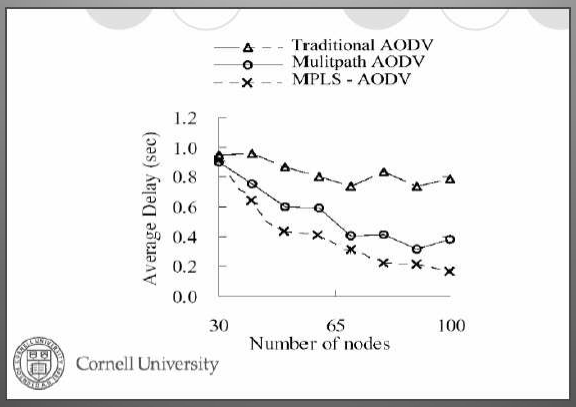
4. Smart Grid Routing Protocols

- Connection of multiple vendor devices, esp. at home metering level ➔ Need for communication protocol independent of lower layers
- C12.22 application layer protocol for sessionless communication, transfer of table data from meters
- 802.11 (wireless) variants: Bluetooth SIG, WiFi
- 802.15 (Wireless Personal Area Networks or WPAN): Z-Wave, 6loWPAN, ***Zigbee***

4. Zigbee Routing Protocols

- Zigbee for low cost ($1 / transceiver, $3 with processor an memory; vs. $3 for Bluetooth), low power, useful for wireless control/monitoring, ex.home/energy automation
- Routing protocol – AODV typical (battery or not; also 'cluster tree routing' if battery operated)
- "Multi Protocol Label Switching" (MPLS) for WAN, assign packets to Equivalence classes when enter network, and thus store all routing info in header to be read.

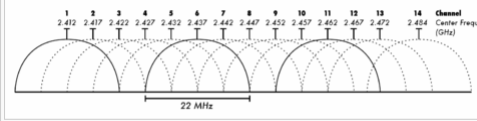
4. MLPS vs. AODV



- Smart Grid Conference, CMU March, 2009
- Coalton Bennett : Review of Communication Technologies for Smart Grid Automatic Metering Systems (Cornell University)

Questions?

< insert funny picture here>



Graphical representation of Wi-Fi channels in 2.4 GHz band