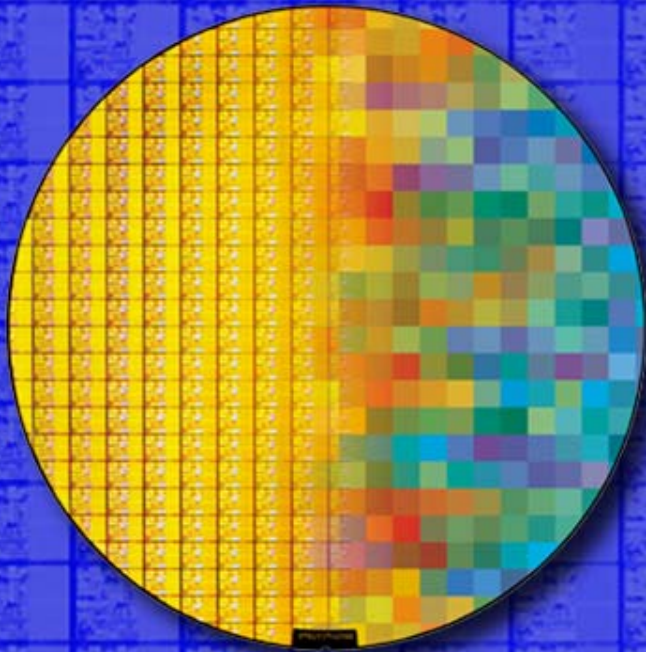
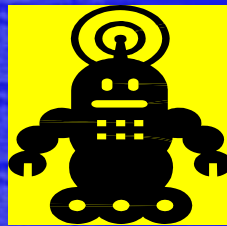


Cognitive requirements for Personal Portable Wireless



Alan Waltho
Intel
11/1/2004



Talk Topics

- **General Requirements- FCC, TV Industry and CR industry**
- **Co-channel interference avoidance**
- **Adjacent channel interference mitigation**
- **Radiated susceptibility mitigation**
- **Future objectives**

Overarching NPRM Requirement

- Prevent interference to incumbent TV receivers
- Concerns expressed by broadcasters and TV manufacturers
 - Prevention of transmission on occupied TV channels within Grade B contour (*Co channel Interference*).
 - OOB emissions could degrade D/U ratios on occupied channels (*Adjacent/taboo channel interference*)
 - Maximum power transmission could overload components of video system (*VCR, cable*)

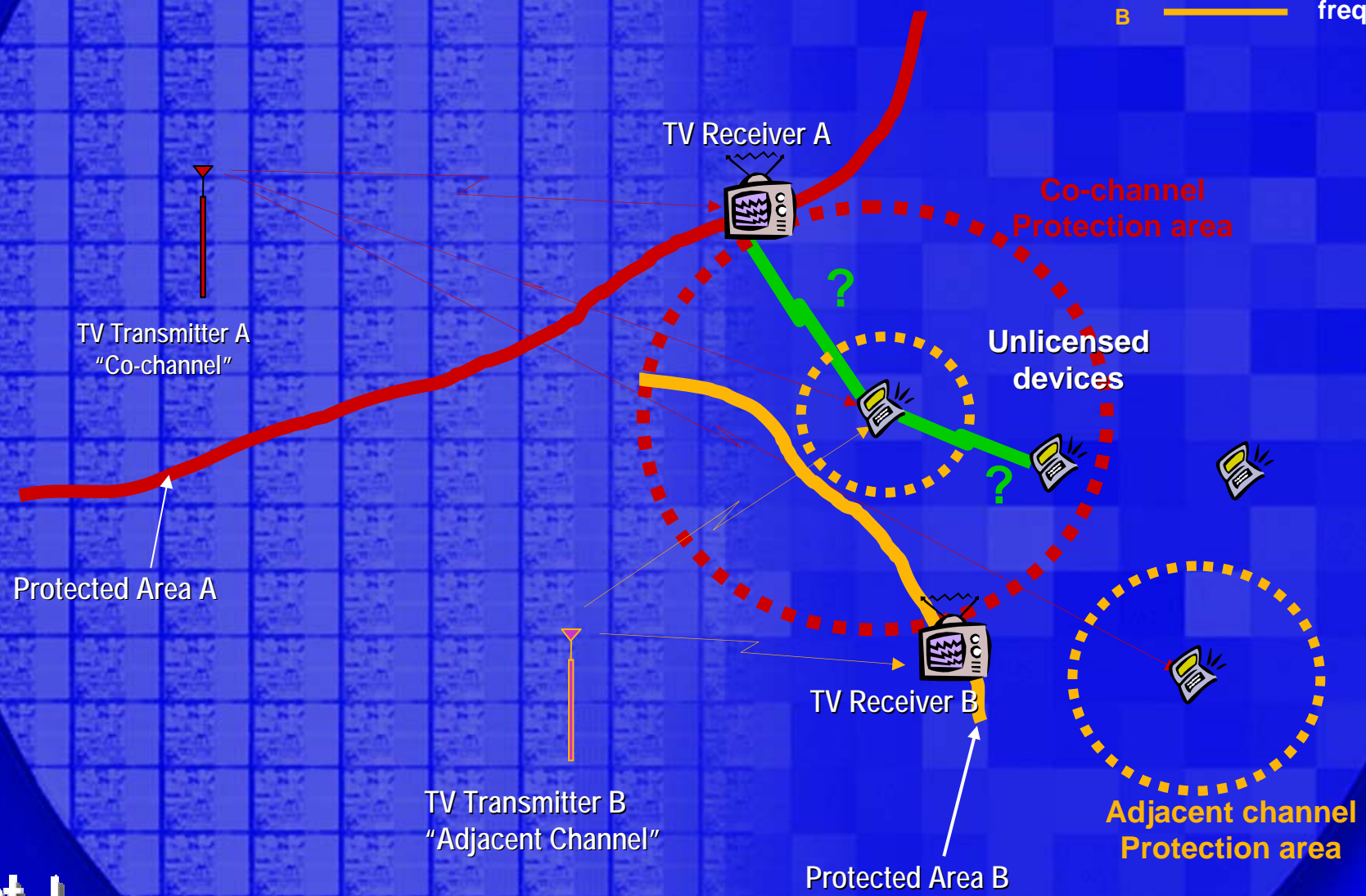


CR Industry concerns surrounding Unlicensed Operation in the TV band

- **Sensitivity threshold of cognitive devices**
- **Operating range of cognitive devices**
- **Frequency reuse issues**
 - Within metropolitan areas or even large apartments
- **Number of unoccupied channels**
 - Terrain profile and local environment realize more complex propagation scenarios in operational range of cognitive devices
- **Sensing techniques**
 - How to detect other signal formats, e.g. OFDM or VSB, far below the receiver noise floor?

TV Band Scenario

A ——— Channel frequency
B ——— frequency



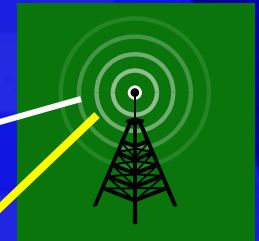
Co channel avoidance

- DTV D/U ratio -23dB gives moderate interference range therefore detect and avoid
- Detect some feature of Broadcast TV signal
 - Pilot tone, frame sync (DTV)
 - Video carrier, line sync (NTSC)
- Indoor CR scenario (*Hidden Transmitter Problem*)
 - Low antenna gain (0 versus 10 dB)
 - Low antenna height (2 versus 10 m)
 - Building losses (Average 5.7, SD 8.6dB)
 - Multipath (4 to 19 dB)

Low detection threshold

Worst Case Hidden Transmitter Scenario

Low probability for detection of occupied channel

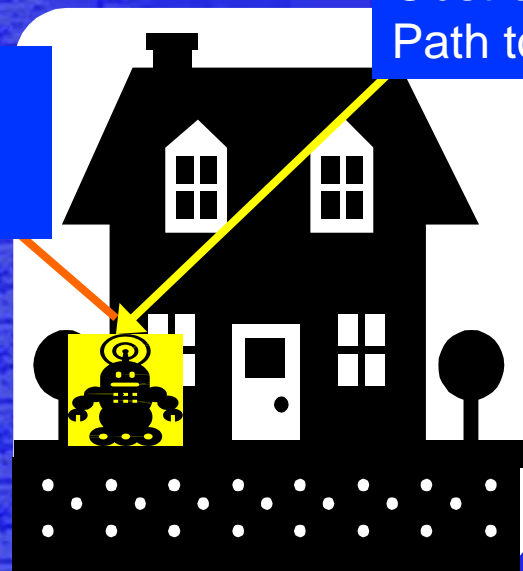


Broadcast Station

Unobstructed path to TV 10 dB antenna

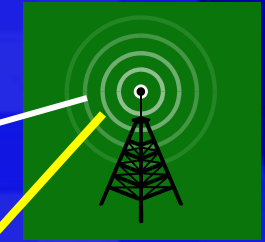
Heavily Obstructed Path to CR

Interference path to TV antenna



Networked scenario

Diversity advantage for occupied channel detection mitigates hidden transmitter problem

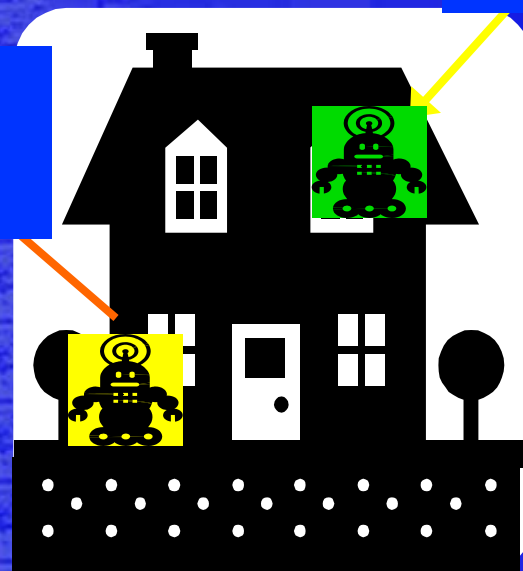


Broadcast Station

Unobstructed path to TV 10 dB antenna

Lightly Obstructed Path to CR

Interference path to TV antenna



Adjacent Channel Interference

- D/U +30 dB (short interference range)
- CR in similar signal environment to TV Rx
- Near TV station high level adjacent channel signals interferes with CR
- Far from TV station CR interferes with low level adjacent channel

Requires Transmitter Power
Control

Adjacent Channel Interference Link Budget Considerations (Outdoor Between Houses)

- Low TV signal correlation between TV and CR [0.2]
- Protected signal Grade B [-83dBm]
- D/U [+30 dB]
- TV antenna gain toward CR [-14 to +10dB]
- Polarization [Horizontal]
- Slant range [>8m in null, >27m in main beam]
- Building penetration losses

Adjacent Channel Interference Link Budget Considerations

(Indoor apartment to apartment)

- Moderate TV signal correlation between TV and CR [0.5]
- Protected signal Grade A [-83 dBm]
- D/U [+30 dB]
- TV antenna gain toward CR [-6 to 0 dB]
- Polarization (random)
- Slant range [>5m]
- Low loss internal walls or floors

Maximum power transmission

- Radiated susceptibility of components of typical video system: 100 mV/m at 1 meter
- Excess field due to 100mW into 6 dBi antenna 30.8dB
 - Increase separation distances [0 to 6 dB]
 - Actual power from CR due to RPC [0 to 24dB]
 - CR antenna gain [0 versus 6 dBi]
 - Lower susceptibility in CR frequency band

Summary - Considerations for CR parameters

- **Vacant channel detection threshold**
 - Detection feature and excess path losses (Hidden Transmitter)
- **Actual power output**
 - Adjacent channel power, adjacent channel D/U and path loss to nearest TV
- **OOB emissions**
 - Actual power output, co channel D/U and path loss to nearest TV
- **Max power output**
 - Interference threshold and protected distance from video component

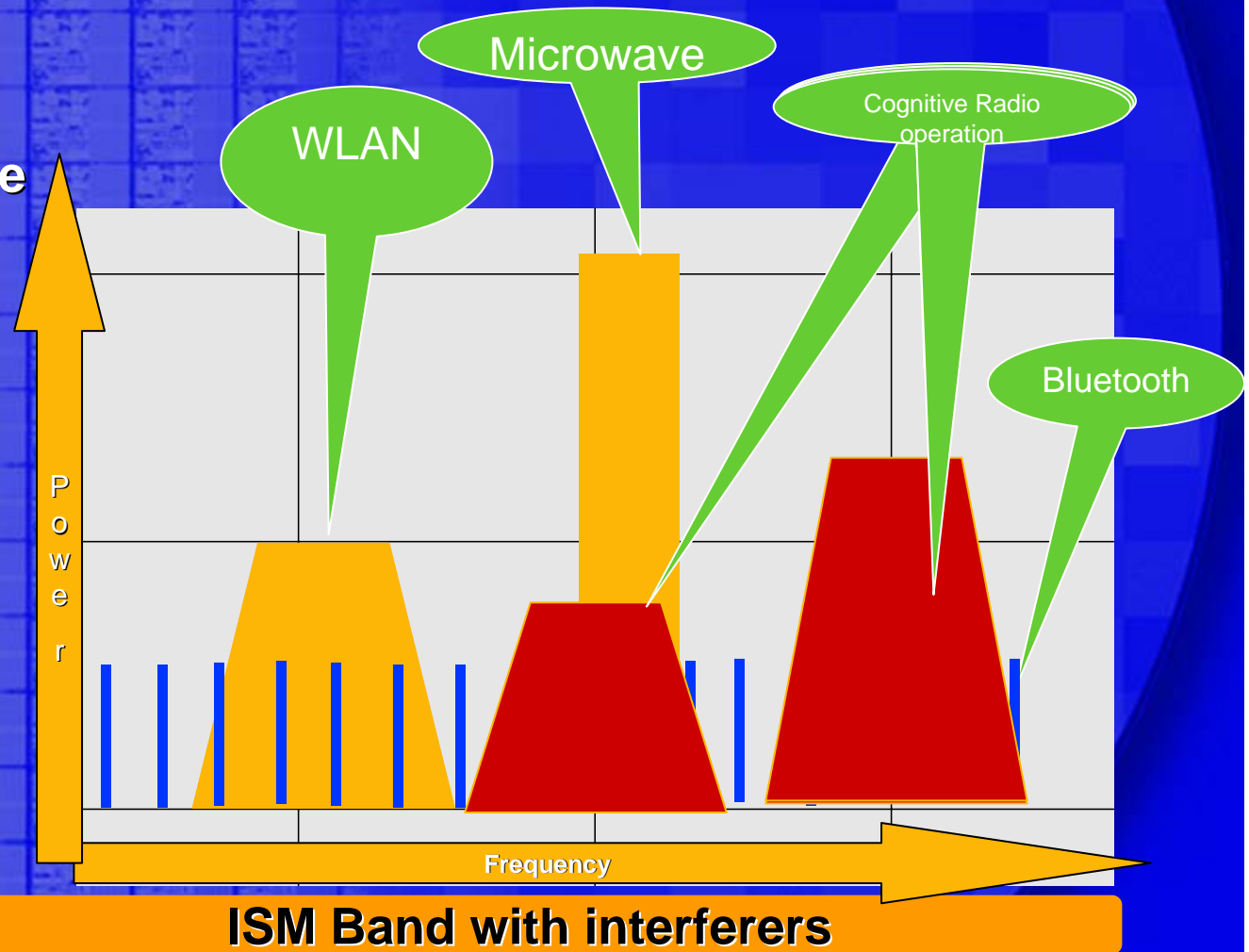
Future Direction - Policy

- **Harmonize International requirements in TV bands**
- **Harmonize bands/services excluded from CR operation**
 - Radio astronomy, safety of life, navigation, remote sensing
- **Define requirements for CR operation in other bands/services**
 - Unlicensed
 - FM Broadcast
 - Fixed point to point
 - Land Mobile bands

Ex: Unlicensed Channel Sensing

- By measuring frequency, bandwidth, power and time occupancy of noise sources Cognitive radios can choose the best operating points

- Uncoordinated WLAN exists on lower channel
- Microwave is periodic
- Bluetooth is across the entire band



Future Objectives-Technical

- **Field evaluation of detection reliability**
- **Reduce false detection**
- **Alternative TV detection techniques**
- **Detection techniques for other waveforms**
- **Develop requirements for international TV bands**
 - **Channel Spacing**
 - **OFDM for DTV**
 - **Legacy PAL, Secam & NTSC systems**