IP CREW

Cognitive Radio Experimentation World

A Performance Comparison of Different Spectrum Sensing Techniques

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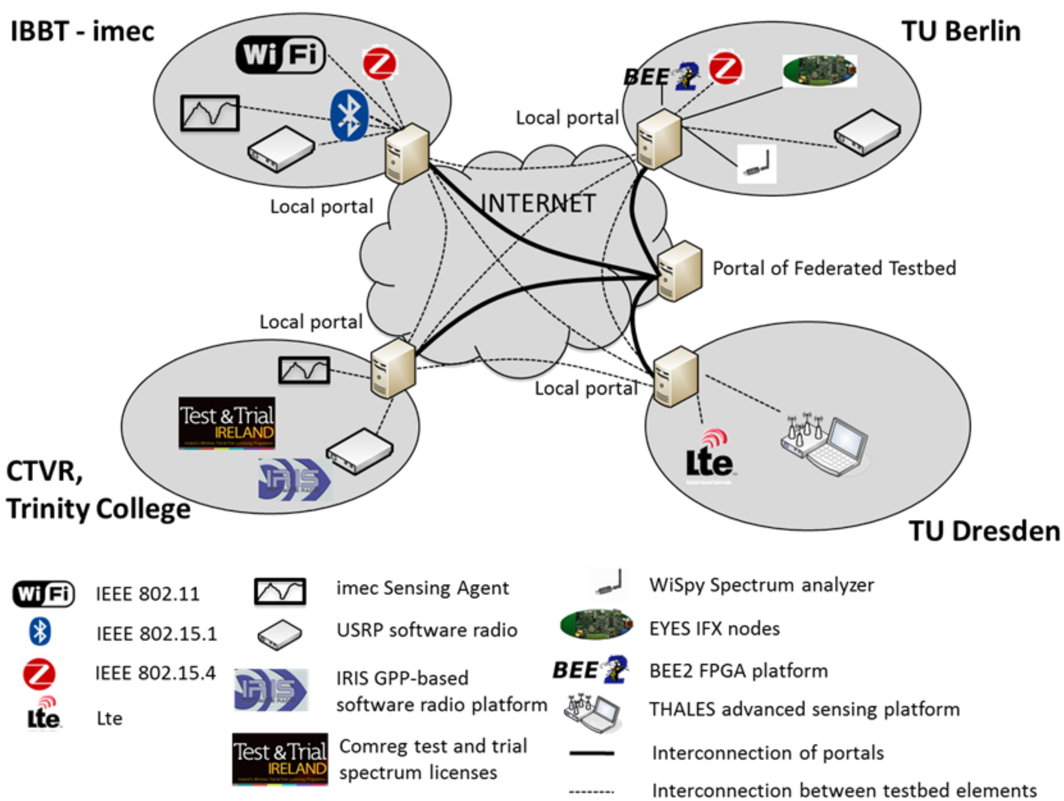
Structure of this Presentation

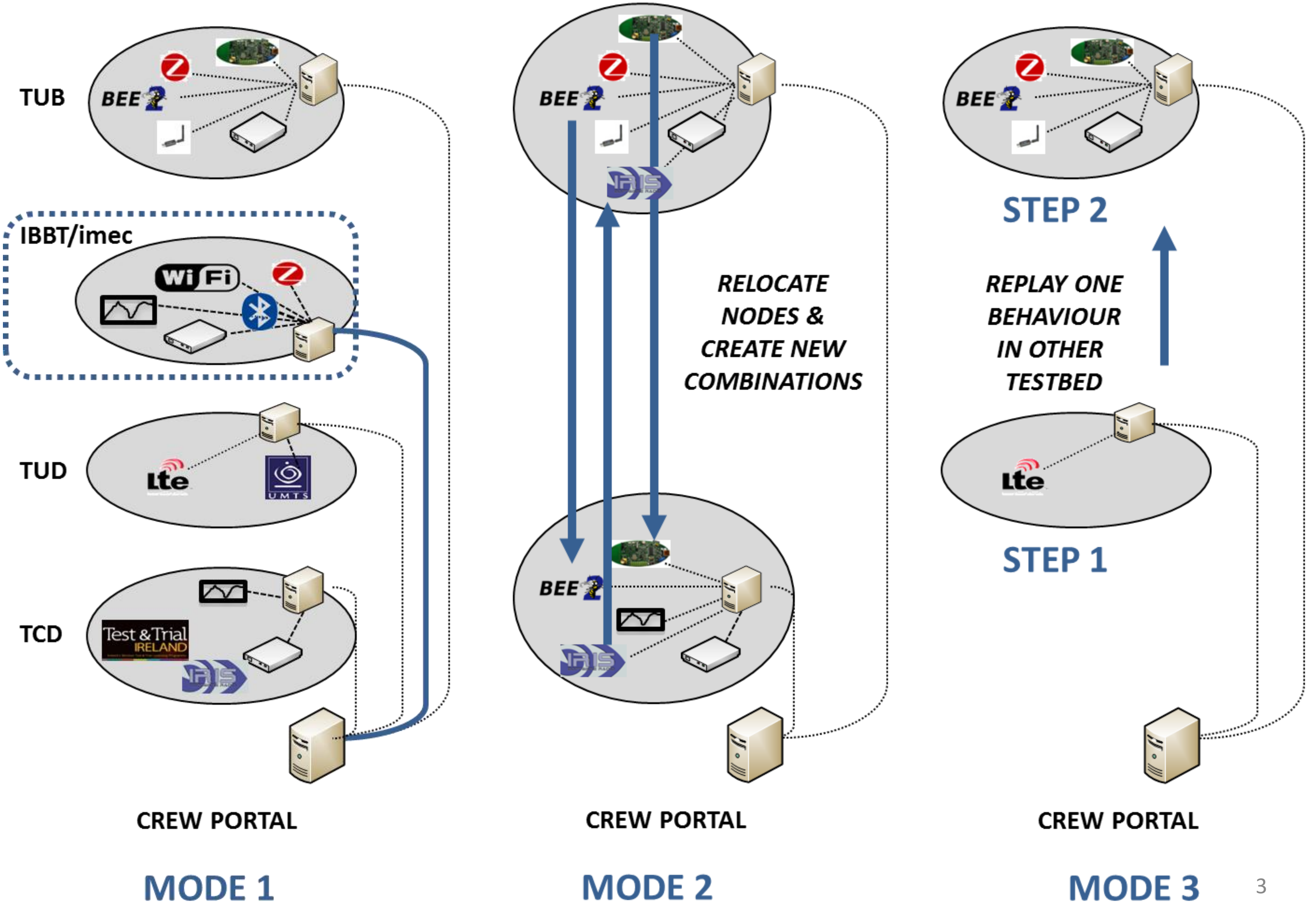
- The FP7 Project CREW
- Purpose of Spectrum Sensing Experiments
- Used Sensing Equipment
- Experimentation Setup
- Results
- Conclusion & Next Steps

The FP7 Project CREW

- Project Partners:
  IBBT, imec, CTVR, TU Berlin, TU Dresden, Thales, EADS
- Project Start: October 2010
- Project Goal: Development of a Federated Testbed for Cognitive Radio Experimentation



The FP7 Project CREW



Purpose of Spectrum Sensing Experiments

- **The CREW Project offers the unique chance to compare a great number of sensing solutions from different project partners**

- **Cross-Platform Study**
  - Comparison of inexpensive off-the-shelf to customized sophisticated solutions
  - Comparison of different processing approaches
  - Benchmarking with respect to
    - Sensing accuracy
    - Sensing speed
    - RF flexibility

Used Sensing Equipment

Wi-Spy 2.4x (MetaGeek, LLC.)

- Low-cost spectrum sensor for 2.4 GHz ISM band
- We used Kismet Spec-tools for Linux OS to acquire power spectral density estimates in a non-propriety format
- Spectrum dumps are performed as fixed bandwidth sweeps of the entire ISM 2.4 GHz band
- The resolution bandwidth is 327 KHz

Used Sensing Equipment

AirMagnet Spectrum XT

- USB product designed for troubleshooting and deploying WLAN networks
- ISM 2.4 GHz/ 5GHz
- internal or external antenna
- Manufacturer specs:
  - amplitude accuracy: +/- 2dB
  - RBW 156.3 kHz
  - sweep time: 64 msec per 20MHz

- Current limitations:
  - CSV log files: 1 report/second
  - scans only full bands (no range config possible)

Used Sensing Equipment

- **TelosB**
  - Sensor network hardware platform developed at UC Berkeley
  - Uses the IEEE 802.15.4-compliant CC2420 transceiver, which can measure RF energy in 2.4 GHz ISM band
    - IEEE 802.15.4 channel (resolution) bandwidth is 2 MHz,
    - Possbile CC2420 center frequencies are 2400, 2401, … 2483 MHz
  - Our setup (TinyOS 2 application)
    - Sweep over spectrum in steps of 2 MHz (e.g. 2400->2402->2404 MHz)
    - Take one RSSI sample per channel (signal power averaged over 192 us)
    - Output data -> total: 2 ms per sample (sampling frequency 500 Hz)

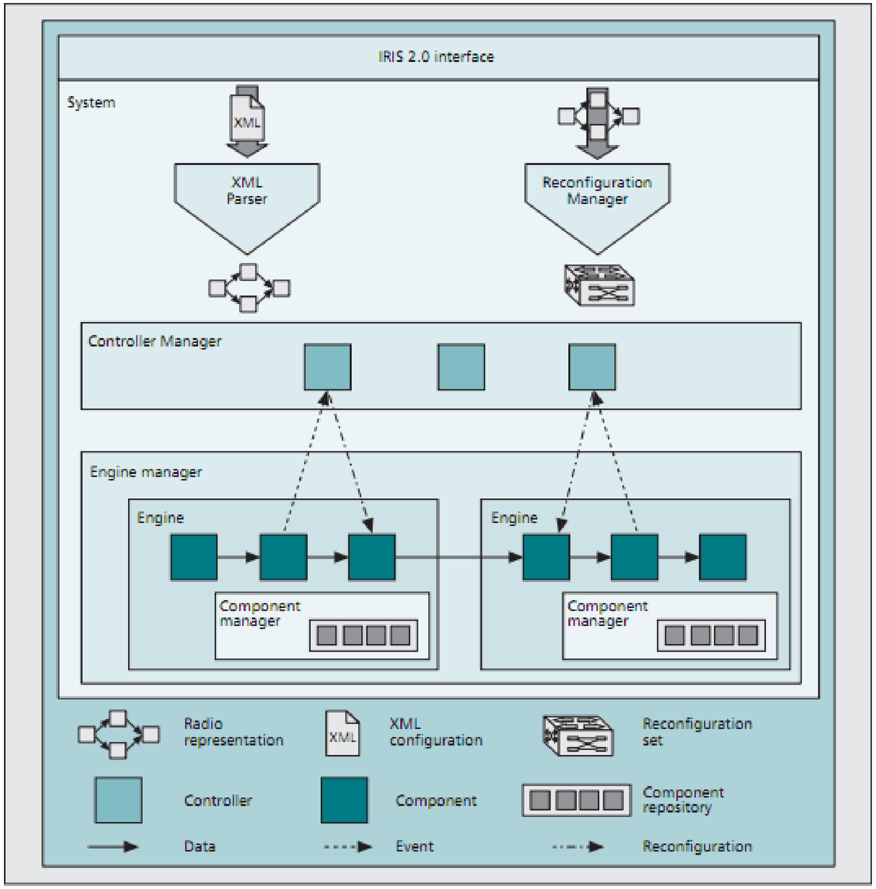
Used Sensing Equipment

USRP1 (Ettus Research)

- Highly flexible low cost RF transceiver.
- Ideal for use in software defined radio.
- Operating frequencies can be changed based on which daughterboard is used.
- For these experiments RFX2400 daughterboard used which operates between 2.3 and 2.9 GHz.
- Can sample up to 8Msamples/sec.

Used Sensing Equipment

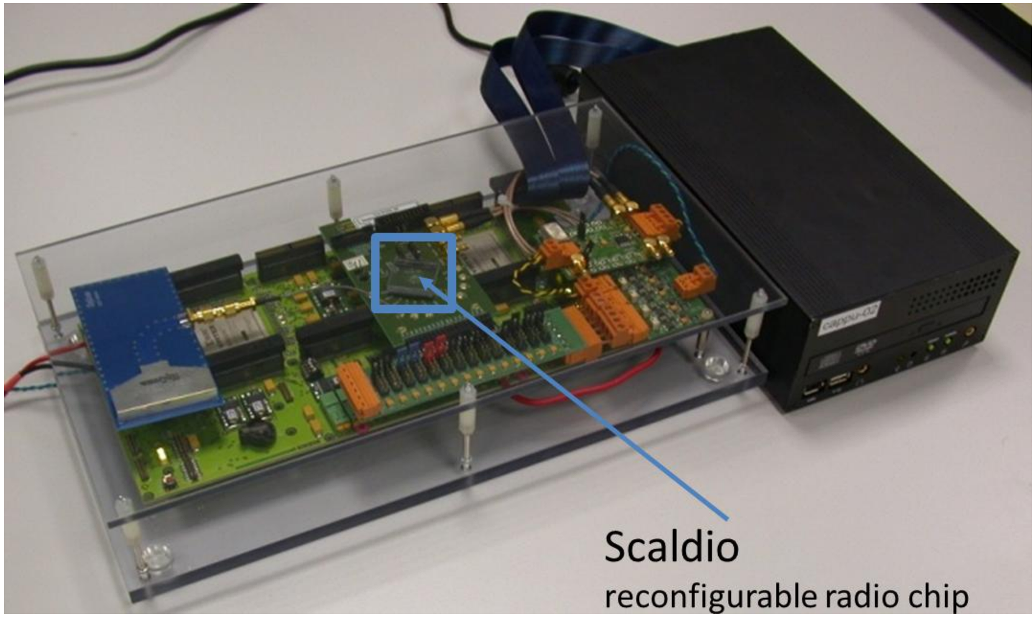
- **Iris**
  - Component based architecture for software defined radio
  - Designed and developed in CTVR, Trinity College Dublin
  - Highly reconfigurable
  - Radio set up as a chain of components
  - Components used can be swapped or have their parameters changed in real time.



Used Sensing Equipment

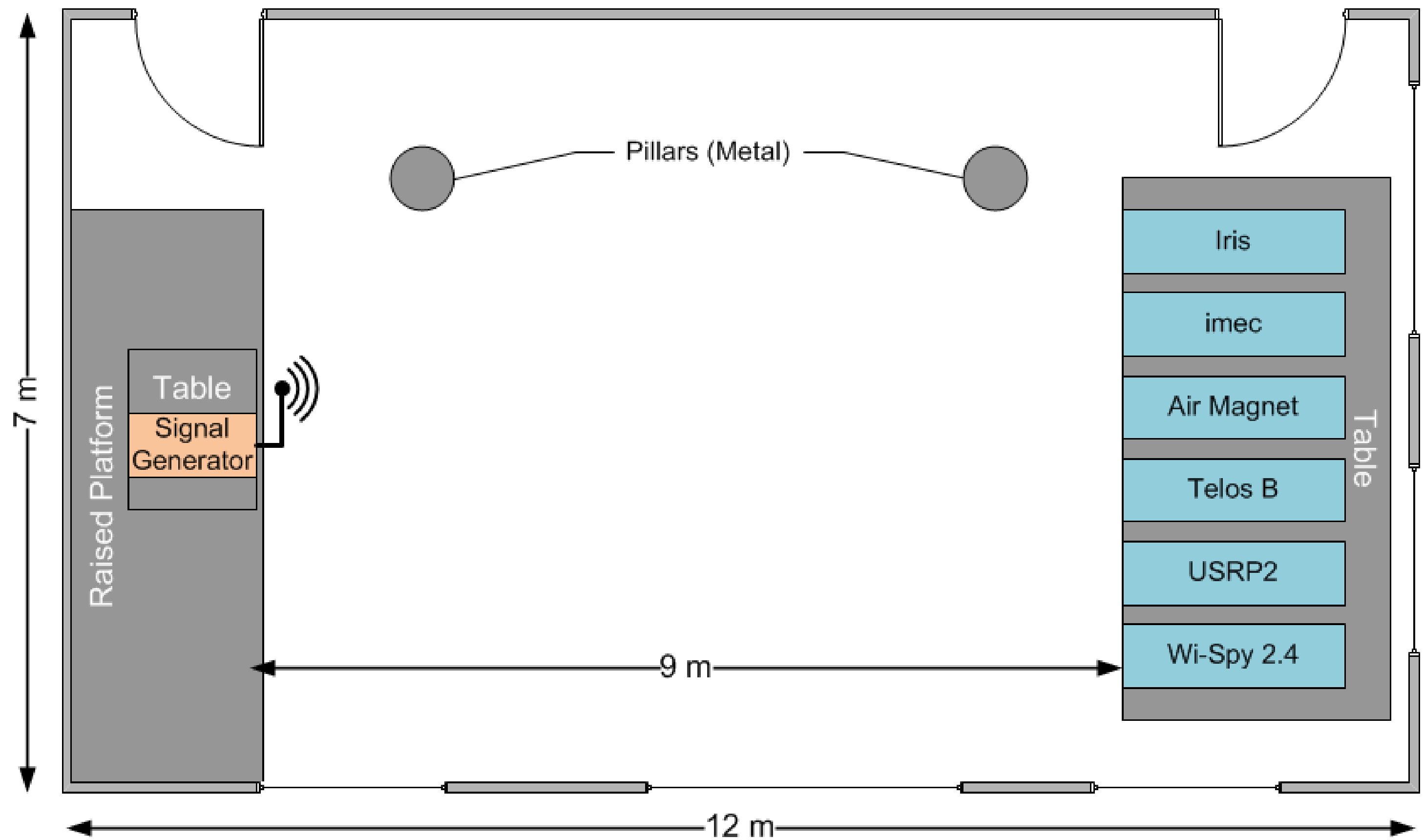
imec Advanced Spectrum Sensing

- Low power/low cost SDR RFIC prototype
- Input range from 0.1 up to 6 GHz
- Programmable channel bandwidth from 1 up to 40 MHz
- On-chip 65MS/s 10b ADC
- 5 mm^2 – 40nm TSMC technology



Experimentation Setup

- **Measurements took place at a lecture room**
  - Signal source on tabl at one side of the room
  - Sensing equipment located on table at other side



Experimentation Setup

Test Signal

- Source: Anritsu MG3700A RF Signal Generator
- Characteristic: DVB-T Signal
  - Center Frequency: 2.477 GHz
  - Bandwidth: 8 MHz
  - CP Ratio: 1/4
  - Power: -4 dBm

Scenarios

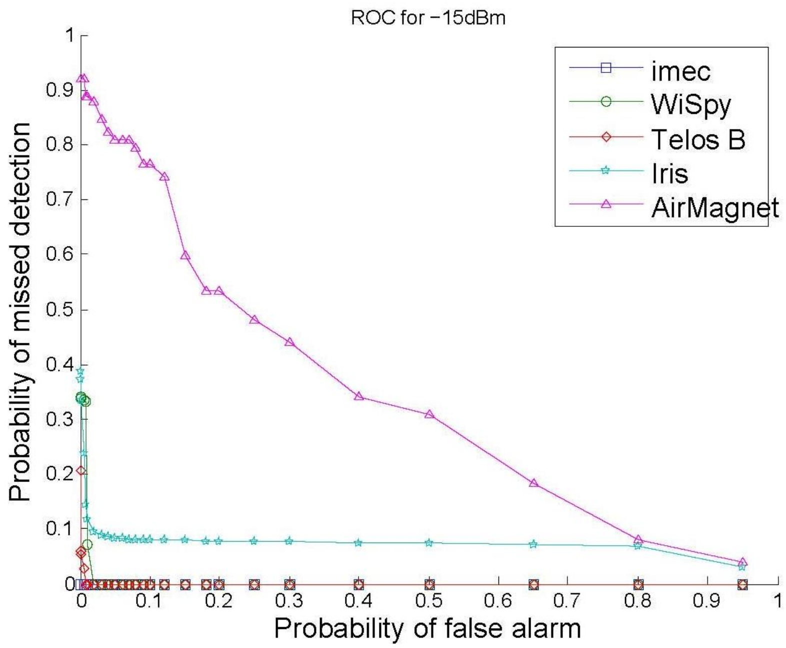
- Slow On/Off Pattern (60 s On / 60 s Off)
- Fast On/Off Pattern (10 ms On / 100 ms Off)
- Change of TX Power (-4 dBm / -15 dBm / -30 dBm)
- Change of Distance between TX and Sensing Nodes
- Change of Center Freq. (2.404 GHz : 8 MHz : 2.496 GHz)

Channel Characteristics

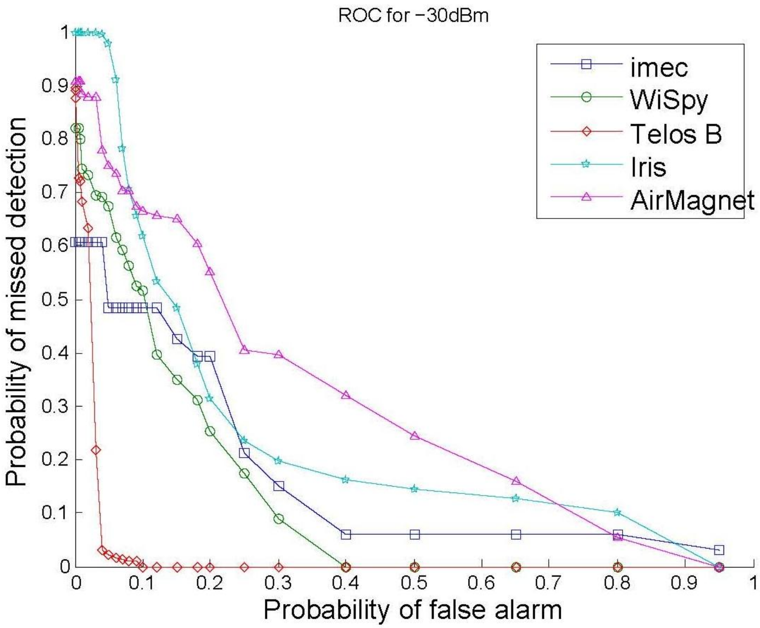
- Static (no people in room)
- Dynamic (10…15 people moving randomly around between TX and sensing nodes)

Medium and low power scenarios

ROC for for Tx power of -15dBm

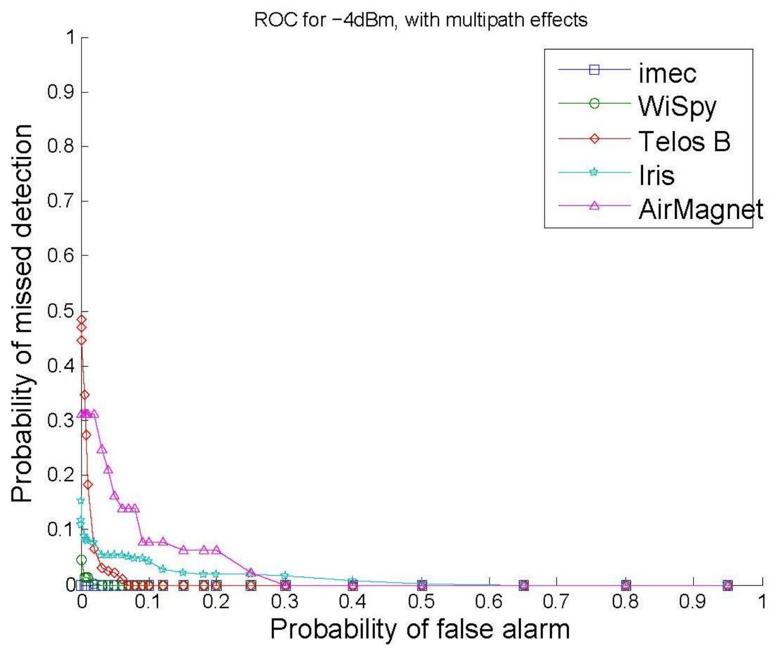


ROC for Tx power of -30dBm

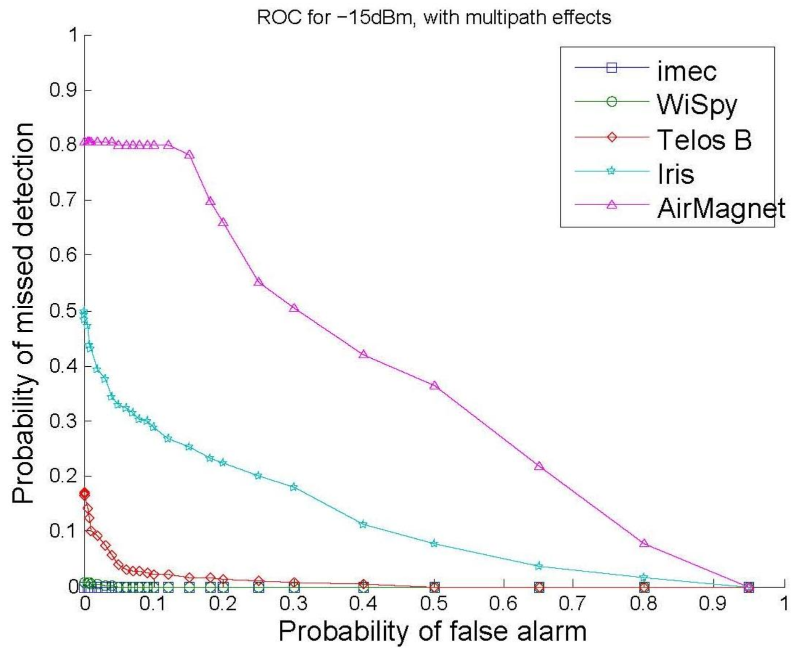


Multipath scenario

Multipath scenario ROC plot for -4dBm



Multipath scenario ROC plot for -15dBm



Conclusions

- **Comparison of sensing devices…**

- **First Step for Standardized and Systematic Comparison of Different Spectrum Sensing Solutions**

- **Pros and Cons of Presented Approach**
  - Realistic signal propagation effects due to real wireless channel
  - Limited comparability of results due to different channel characteristics between signal source and each sensing node

Next Steps

- **Improving Comparability and Objectivity of Results**
  - Development of benchmarking criteria for wireless spectrum sensing
  - Establishment of a better reproducible signal propagation environment
    - Usage of coax cables instead of wireless channel
    - Usage of fading channel simulator