SEVENTH FRAMEWORK PROGRAMME

CREW WinnComm tutorial

2: CREW spectrum sensing

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Sensing in CREW

- CREW sensing hardware overview
- Heterogeneity of the sensing solutions measured
- Sensing experiments examples
- Conclusions

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CREW sensing solutions

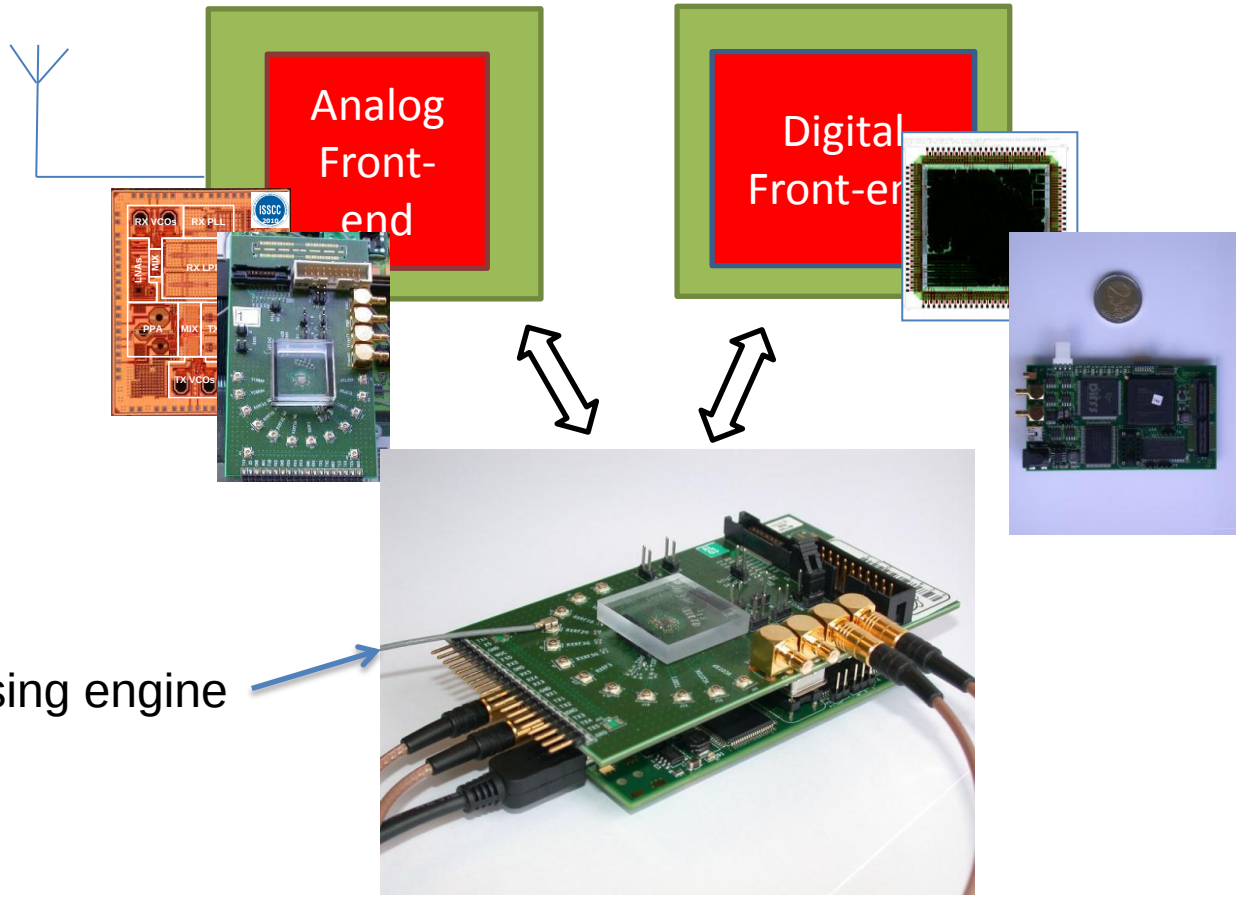
- Airmagnet
  - Commercial USB device from Fluke
  - Both the 2.4 and 5GHz ISM bands.
  - Bundled software was used to record spectrum activity

- TelosB
  - Commercial USB device, 2.4 GHz ISM band.
  - Customized Tiny-OS application for sensing

- SDR1: USRP
  - Universal Software-defined Radio Peripheral
  - Commercial hardware with customized software for sensing

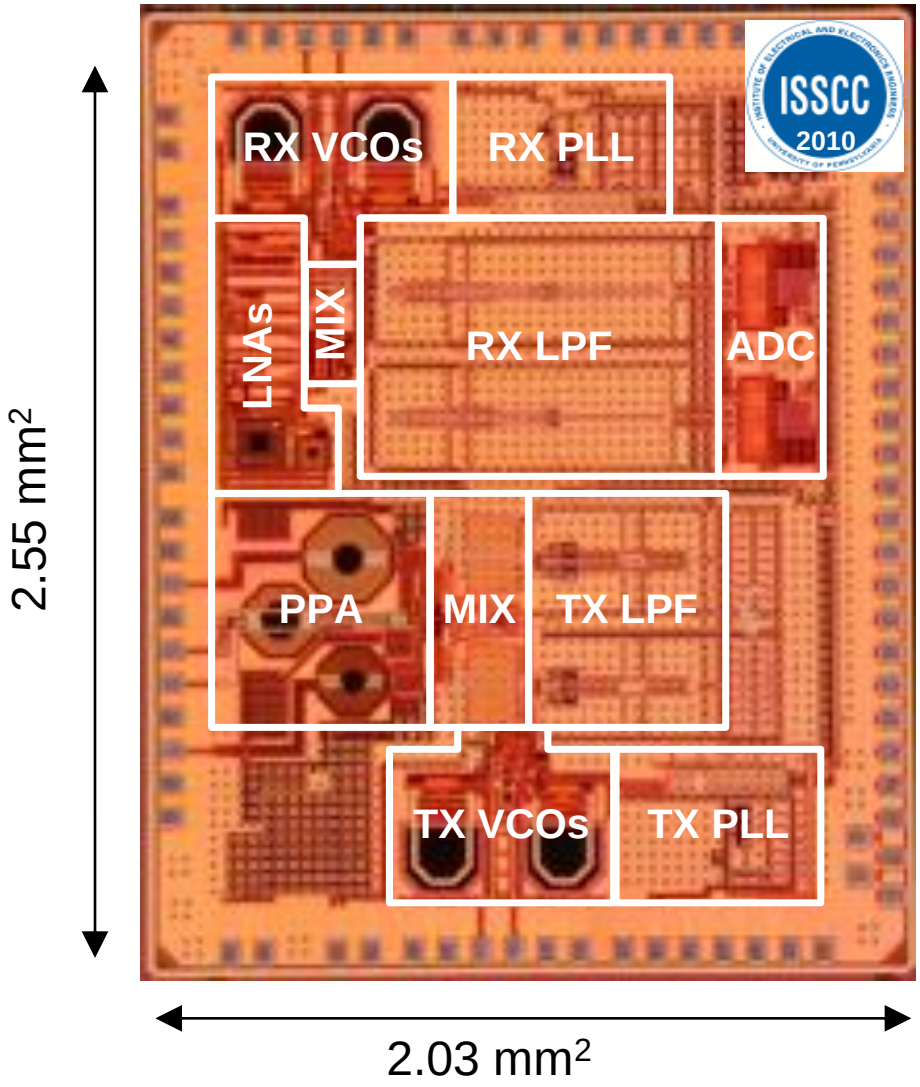
- SDR2: IMEC sensing agent
  - Both hardware and software are customized design
  - Up to 6GHz

imec advanced spectrum sensing

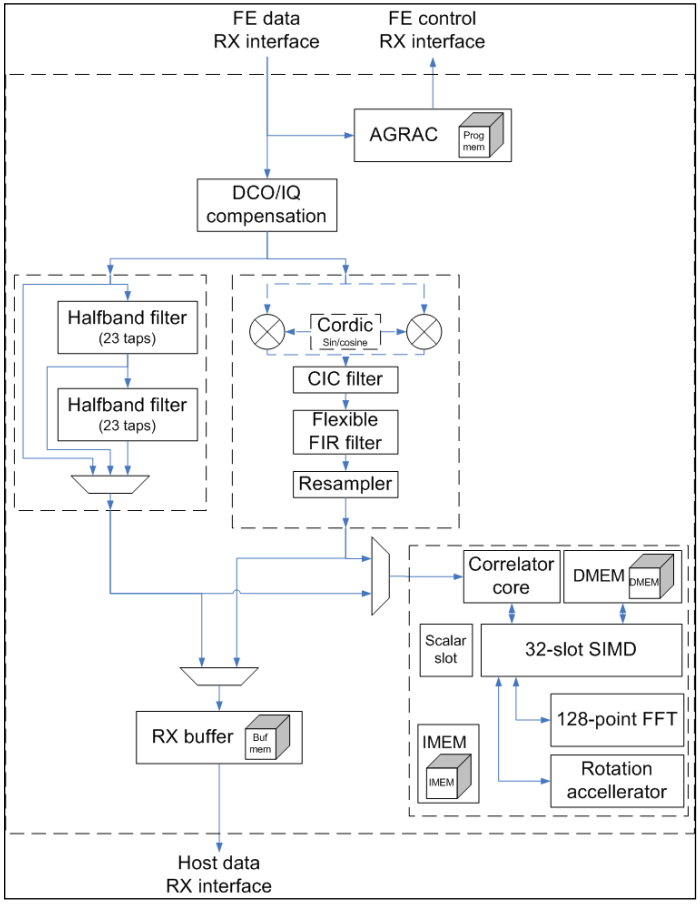


Scaldio-2b: a 5 mm² reconfigurable transceiver in 40nm CMOS

- Full transceiver
- RF input from 100MHz up to 6 GHz
- Baseband BW from 1 up to 40 MHz
- On chip SAR-ADC
  - 10b
  - 65 Ms/s
- 40nm digital 1.1/2.5V CMOS TSMC technology
- Performance comparable to SotA single-mode radios
  - Area: 5 mm²
  - Power consumption: 40-100 mW depending on mode



Digital front-end for sensing (DIFFS)



Low-power synchronization

65 nm TSMC

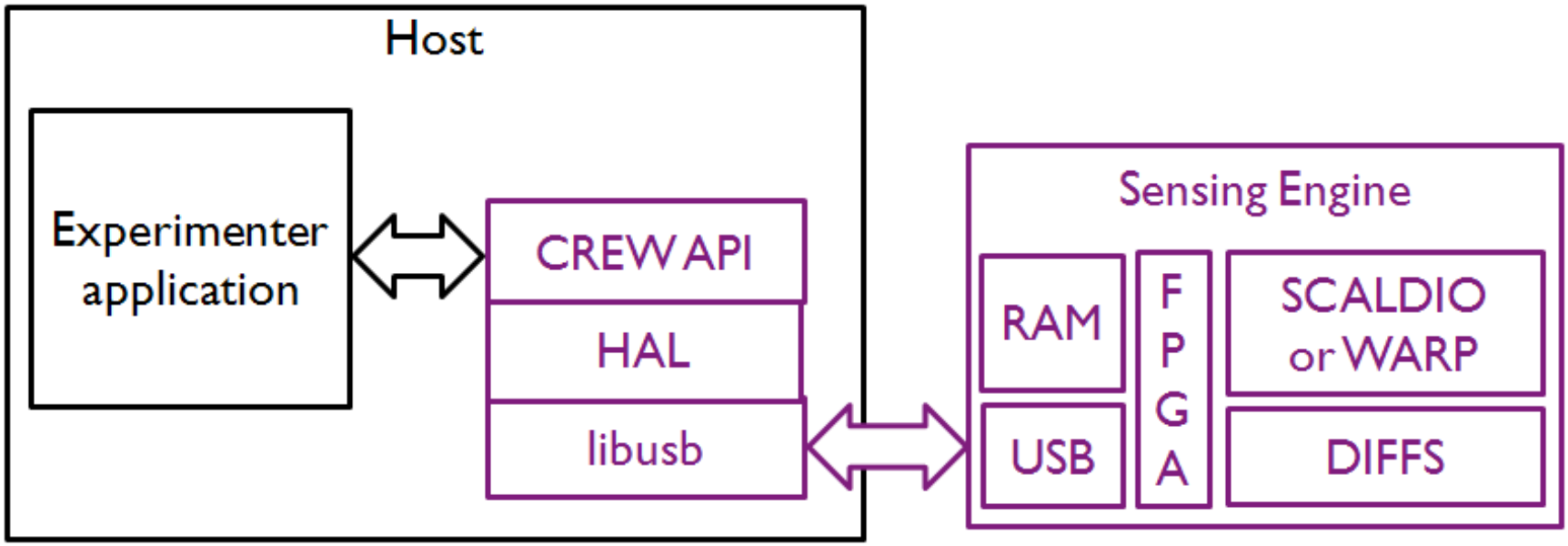
Flexible filter/mixer/resampler

- support for ΣΔ
- future standards
- concurrent reception/sensing

Sync/sense engine: SIMD

- dedicated accelerator cores
- capable of “sensing” + “syncing”

Ways to interact with the sensing engine

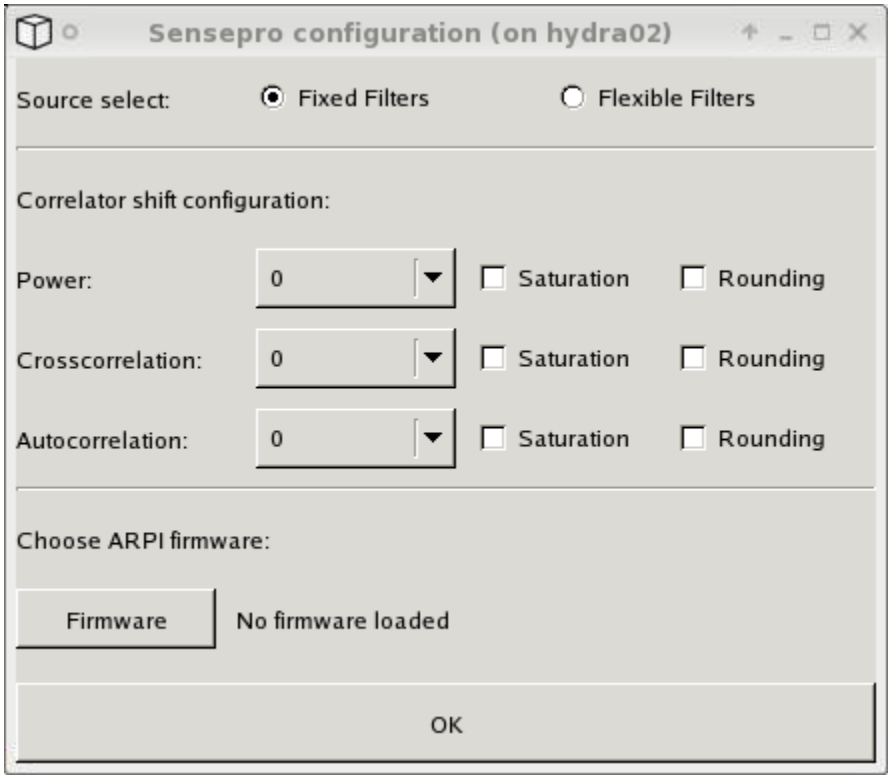


E.g., API support for the WARP RF front-end

- **Detector**
  - Algorithm
    - Power measurement (vs threshold)
    - FFT (vs threshold) - [32/64/128] bins
  - Gain configuration
    - Automatic Gain Control
    - Fixed gain
- **Mode/channels**
  - Bluetooth / 1 .. 80
  - Zigbee / 1 .. 15
  - WLANg / 1 .. 13
  - WLANn / 1 .. X

E.g., Configuring the DIFFS through the HAL

- Input datapath selection
- Correlator configuration
- Firmware selection for the SIMD processor



Many more information in the CREW deliverables/portal

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Heterogeneity of the sensing solutions

	RF frontend	Signal processing	cost
imec	 very wide frequency span, high speed ADC	 Embedded uP, Fast speed low flexibility	HW + SW customized design
USRP	 less wide frequency span, high speed ADC	 GPP, high flexibility low speed	HW Commercial available, around 2k euro
Airmagnet	 less wide frequency span, low speed ADC	 Hardware, low flexibility, high freq resolution	Commercial available, HS+SW around 2k euro
TelosB	 less frequency span, slow ADC	 Hardware, low flexibility, low freq resolution	Commercial off-the-shelf device, <100

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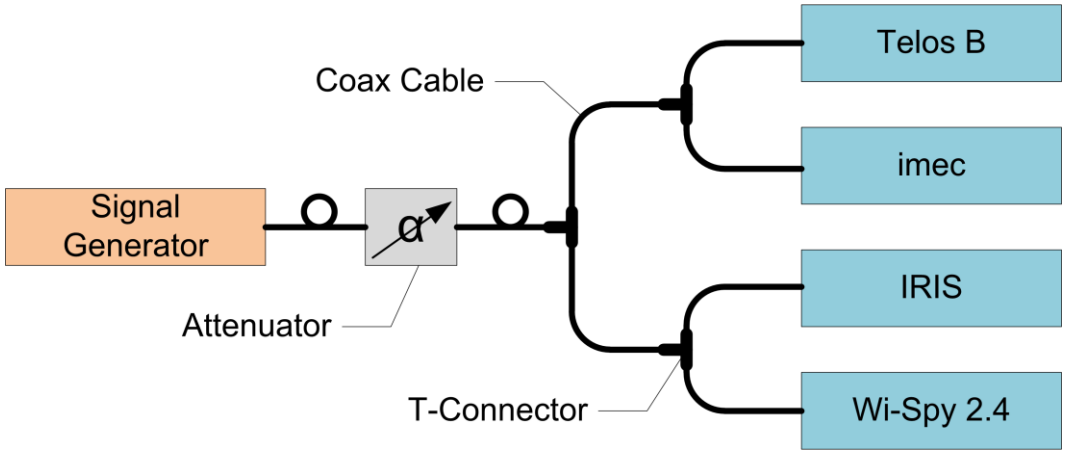
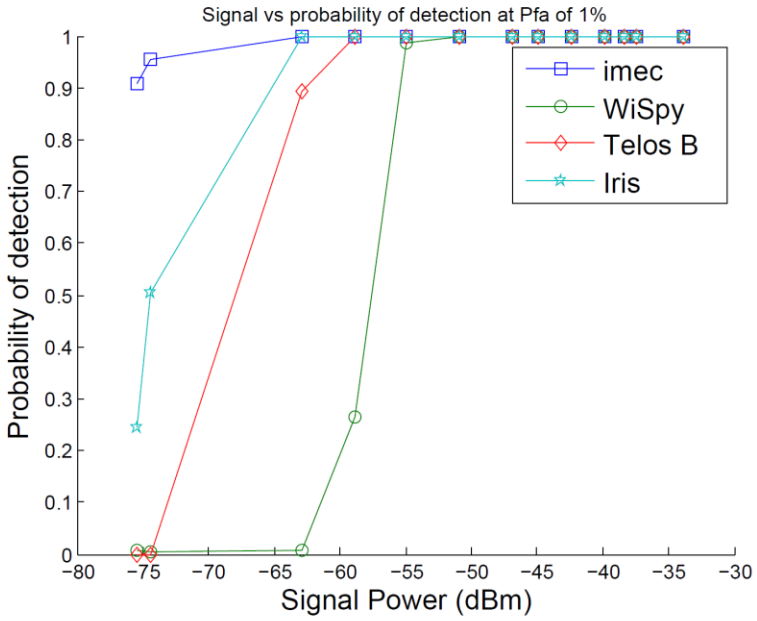
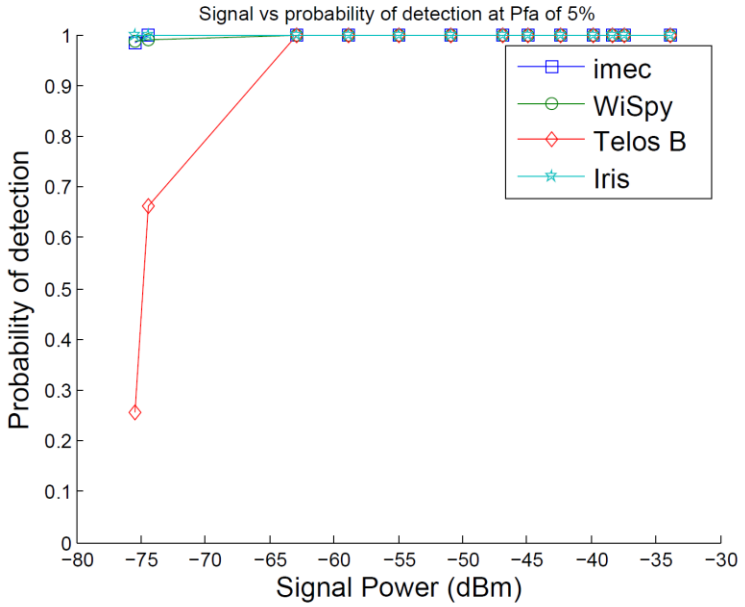
Calibrate the hardware

Probability of Detection of the Signal vs. TX Power for Coax Cable Connection



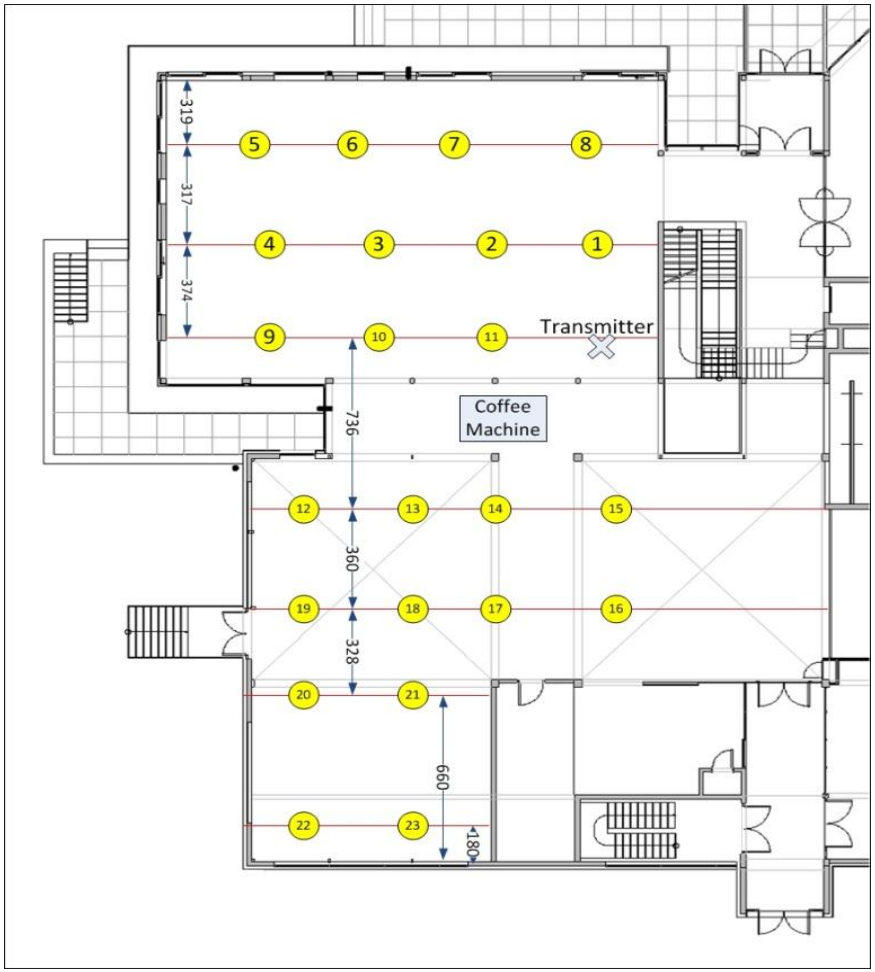




Prob. for False Alarms: 1 %

Prob. for False Alarms: 5 %

Heterogeneous sensing experiment in imec cafeteria

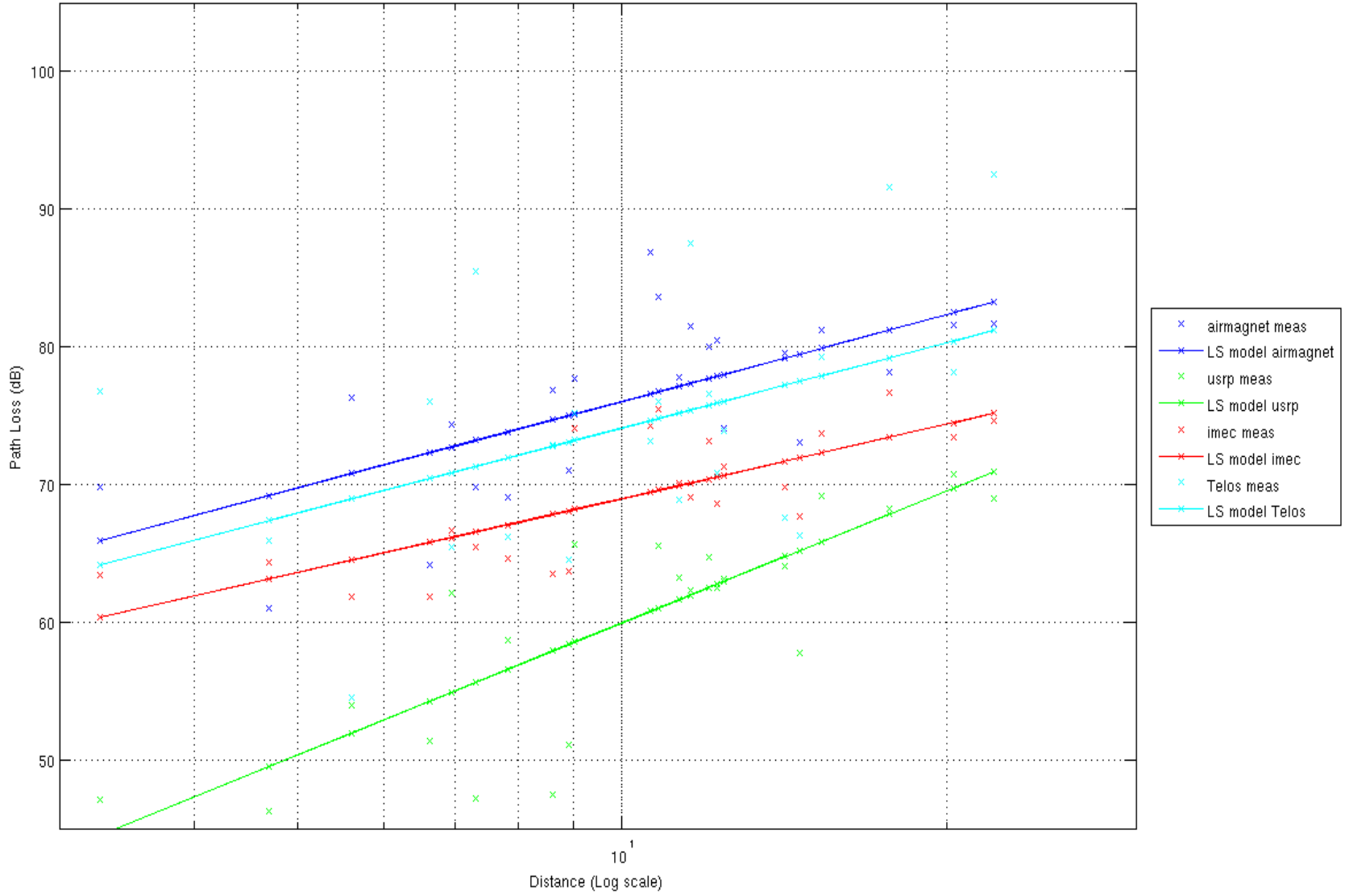


Experiment setup

- **Aim : Test the robustness of distributed heterogeneous sensing.**
- **Assume imec cafeteria is a large indoor environment**
- **Transmitter at fixed location, continuous transmission of 20 Mhz OFDM signal at 2.47GHz**
- **Heterogeneous devices are used to measure spectrum at all locations.**
- **Least Squares method used to generate the pathloss model for each device.**

Heterogeneous sensing experiment in imec cafeteria

Pathloss vs distance



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- **Sensing experiments examples**
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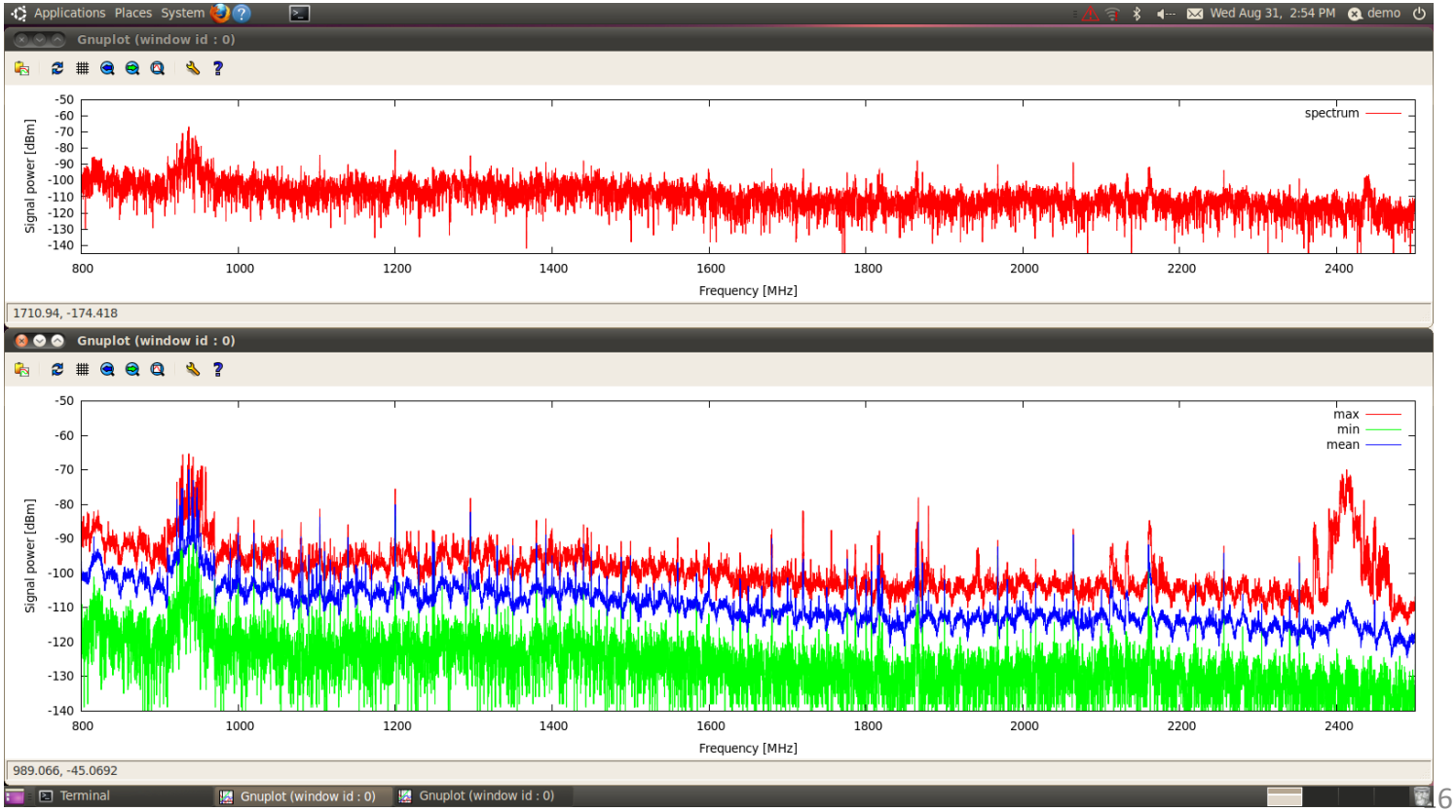
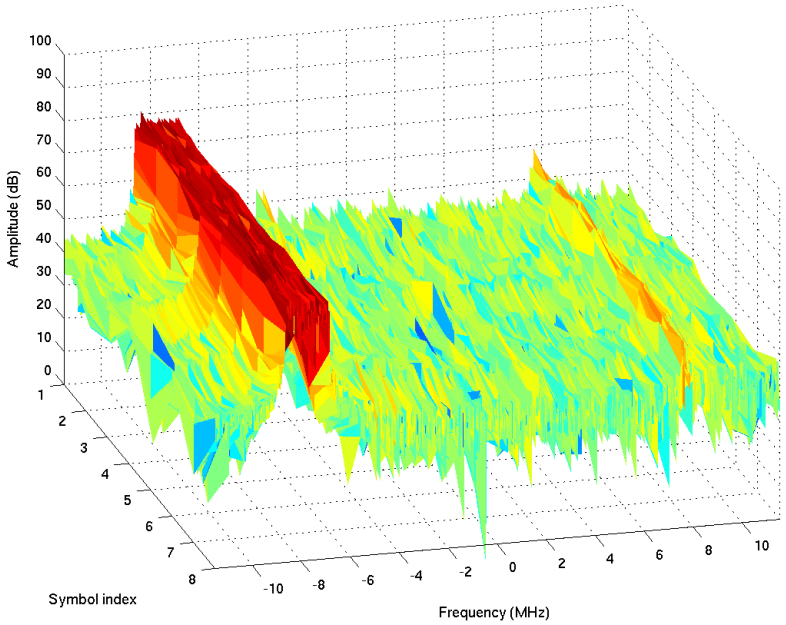
Experiment output

- **Wide-range frequency scan on DIFFS and SCALDIO**
  - 800 MHz – 2,5 GHz
  - 128 point FFT / 20 MHz band

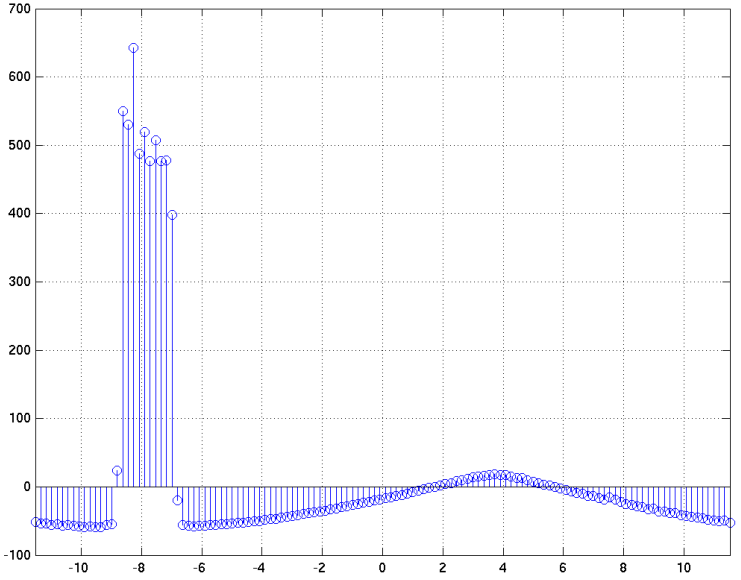


Sensing of LTE: the TUD LTE-signal



20 MHz LTE signal with 10 active PRB's
Wirelessly transmitted
2.6 GHz band

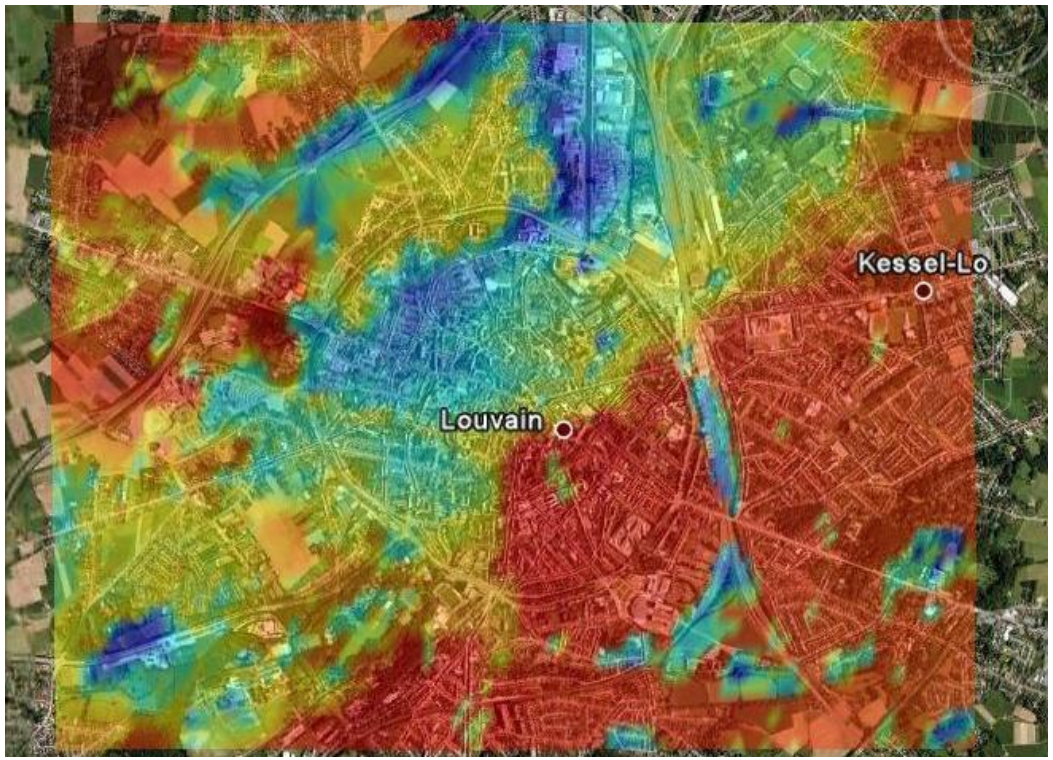
Synced and active PRB's found



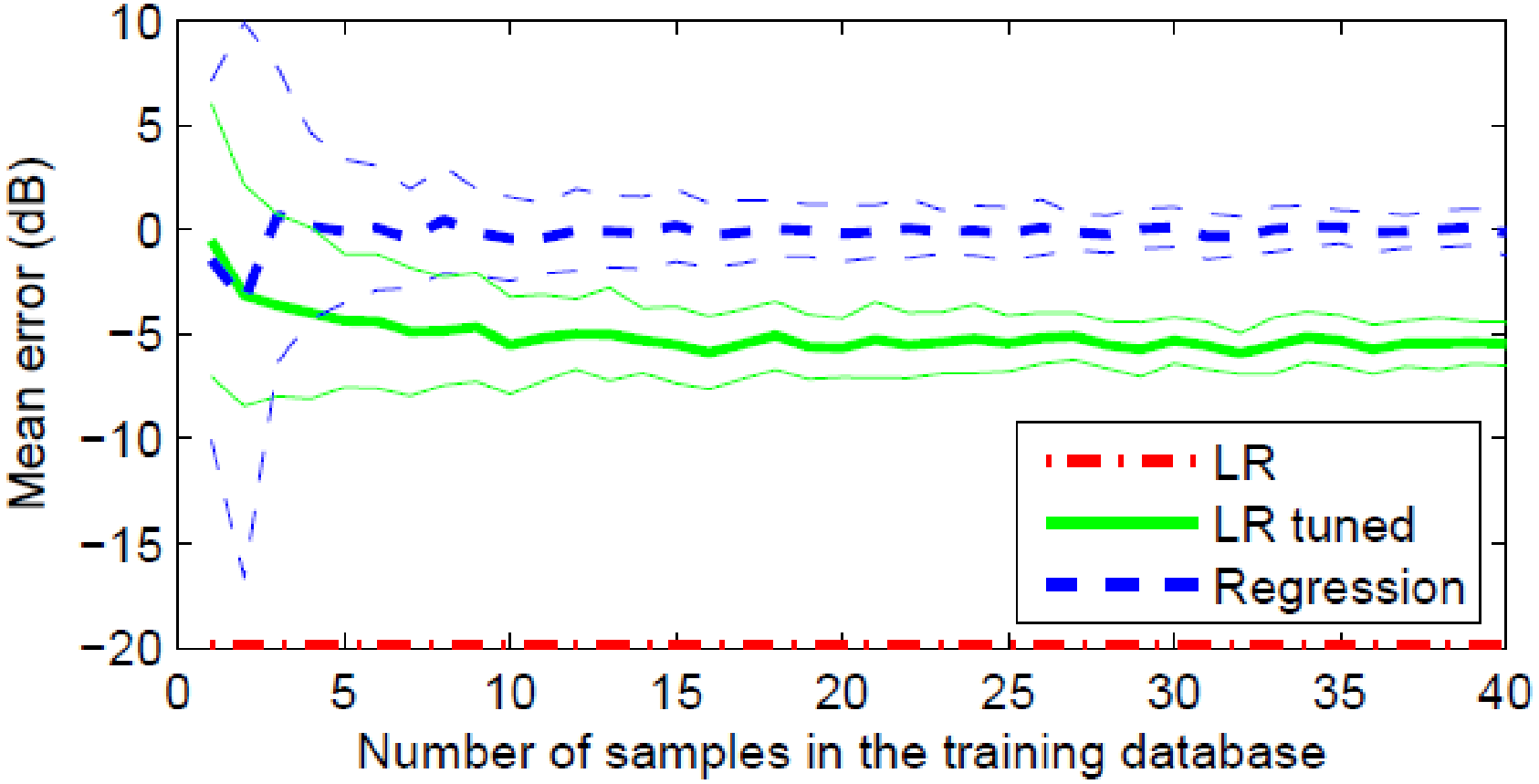
Milestones for usage scenario ‘context awareness’

- **Year one: local sensing for ISM, LTE, DVB-T √**
- **Year two: distributed sensing**

DVB-T reception in Leuven



Sensing versus database/model

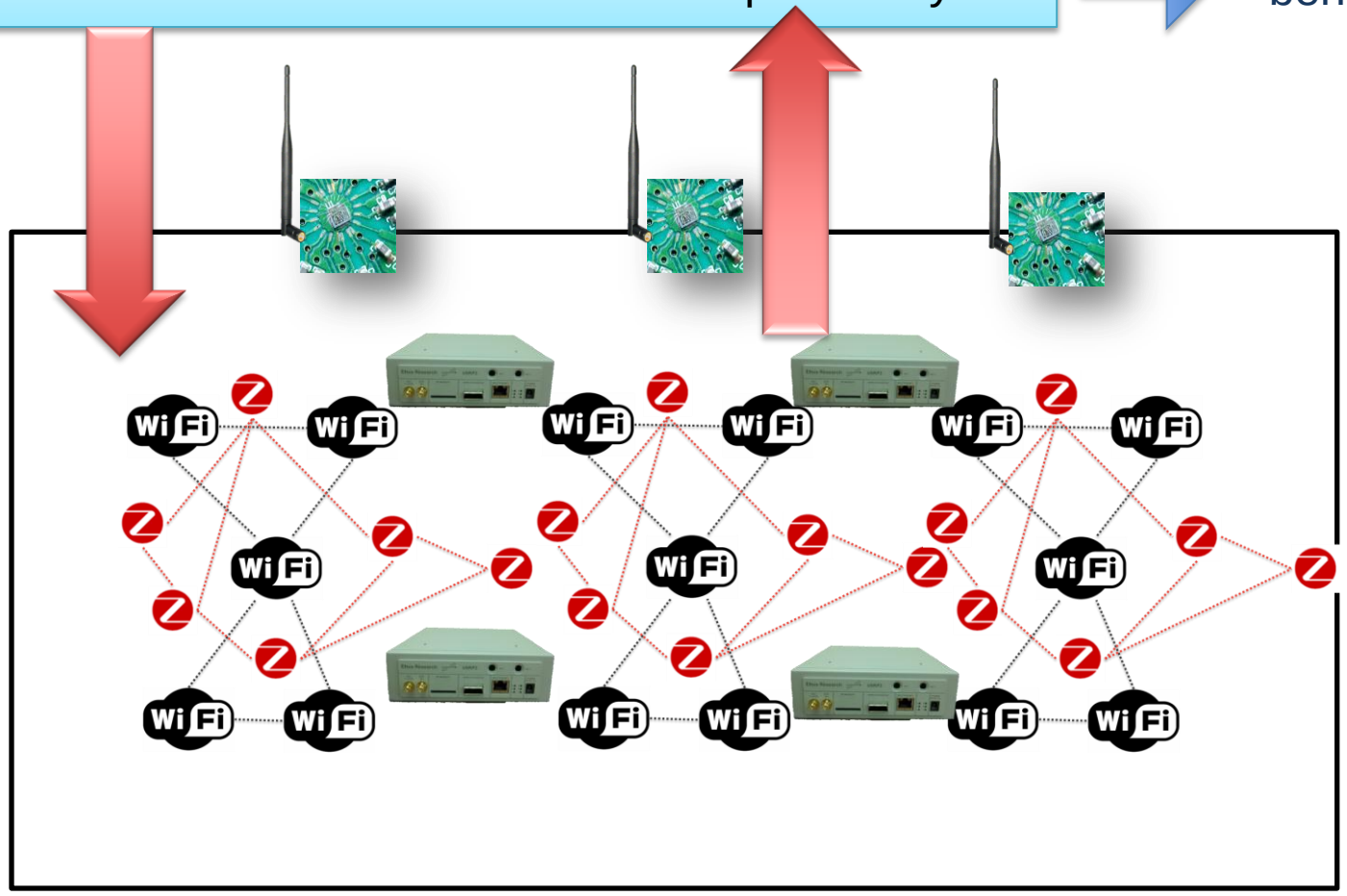


Controlled experimentation environment

inject RF interference
and/or background traffic

MONITORING
➔ repeatability

wireless
benchmarking



experimentation environment

CR hardware available to experimenter

Conclusions

- **Many sensing solutions in CREW**
  - Off-the shelve and custom designed
  - Integrated in testbeds
  - Allow experiments for local and distributed sensing
  - Allow benchmarking of experiments

- **We are open to your ideas for meaningful sensing experiments**
  - New algorithms
  - New approaches (database, distributed)
  - New scenarios

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