Cognitive Wireless Mesh Network without Common Control Channel Evaluated in NS-3

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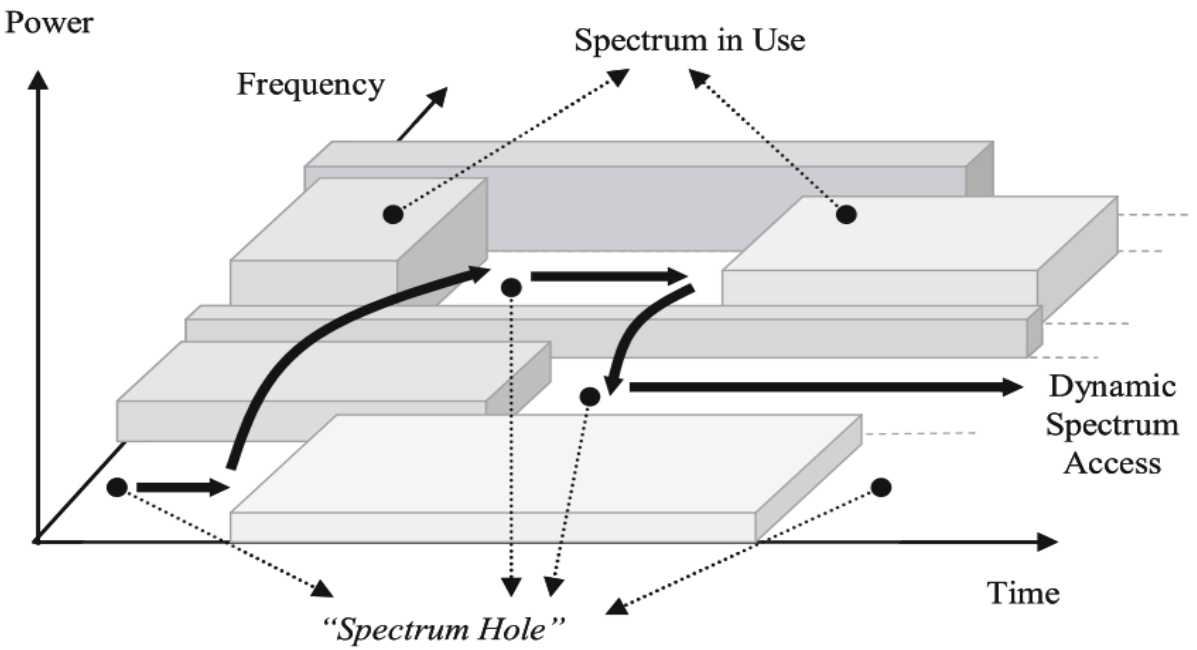
CPqD Ecosystem

Private Law Foundation "Private company without shareholders" - Profit Reinvested

Location: Campinas – São Paulo - Brasil

CPqD Ecosystem

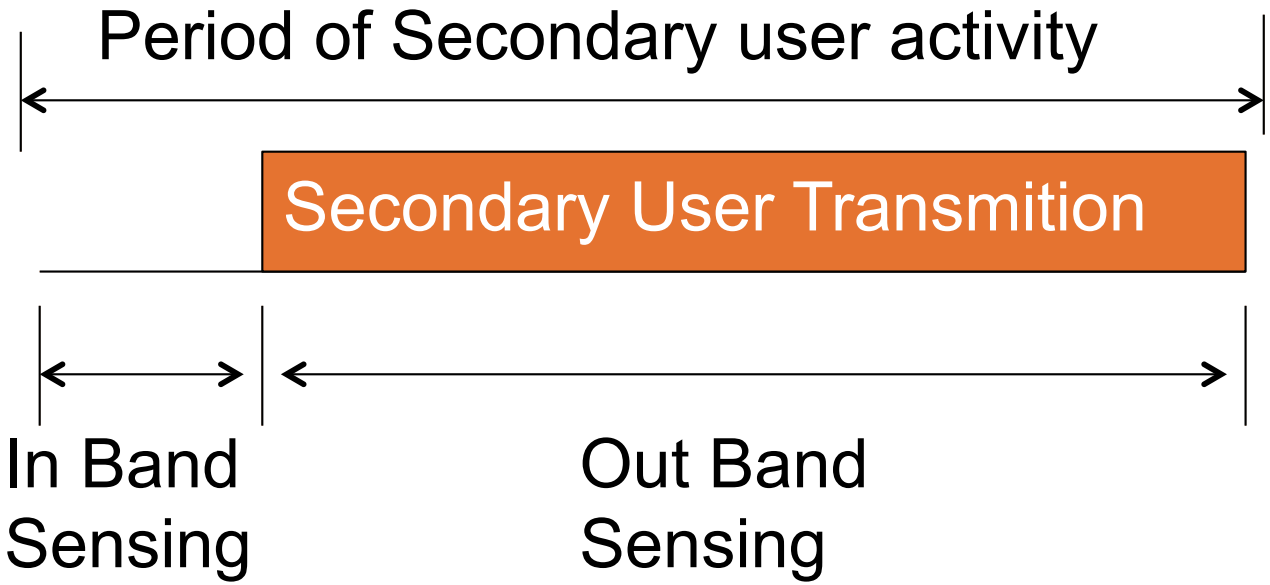
What is Cognitive Radio?



- A "Cognitive Radio" is a radio that can change its transmitter parameters based on interaction with the environment in which it operates.

CRAHNs: Cognitive radio ad hoc networks
Ian F. Akyildiz, Won-yeol Lee, Kaushik R. Chowdhury , 2009, 810-836.

Main requirements of Cognitive Networks



- Primary network can not be interfered by secondary network.
- Maximize secondary network Throughput.

Cognitive network procedures

Typical Cognitive network procedure	Non typical cognitive network procedure
In band sensing + out band sensing	Out band sensing
Spectrum sensing with high sensibility to protect Primary User.	Spectrum sensing with high sensibility to protect Primary User.
Non any specific algorithm to optimize throughput over Non common control channel	Algorithm to optimize throughput over Non common control channel and sensibility(MC-OIM).

*MC-OIM (Multi Channel - One Interface Manager)

Multi Channel - One Interface Manager (MC-OIM) algorithm

$IsAlive = 1$, the communication link between routers is working normally.

$IsAlive = 0$, the communication link between routers has any fault.

Algorithm 1 Main step by step of MC-OIM algorithm

STEP 1: Message transmission between MCMR and FCMR to check link communication between routers

1: Check $IsAlive_{jk}, j \neq k, \{j, k \in G\}$

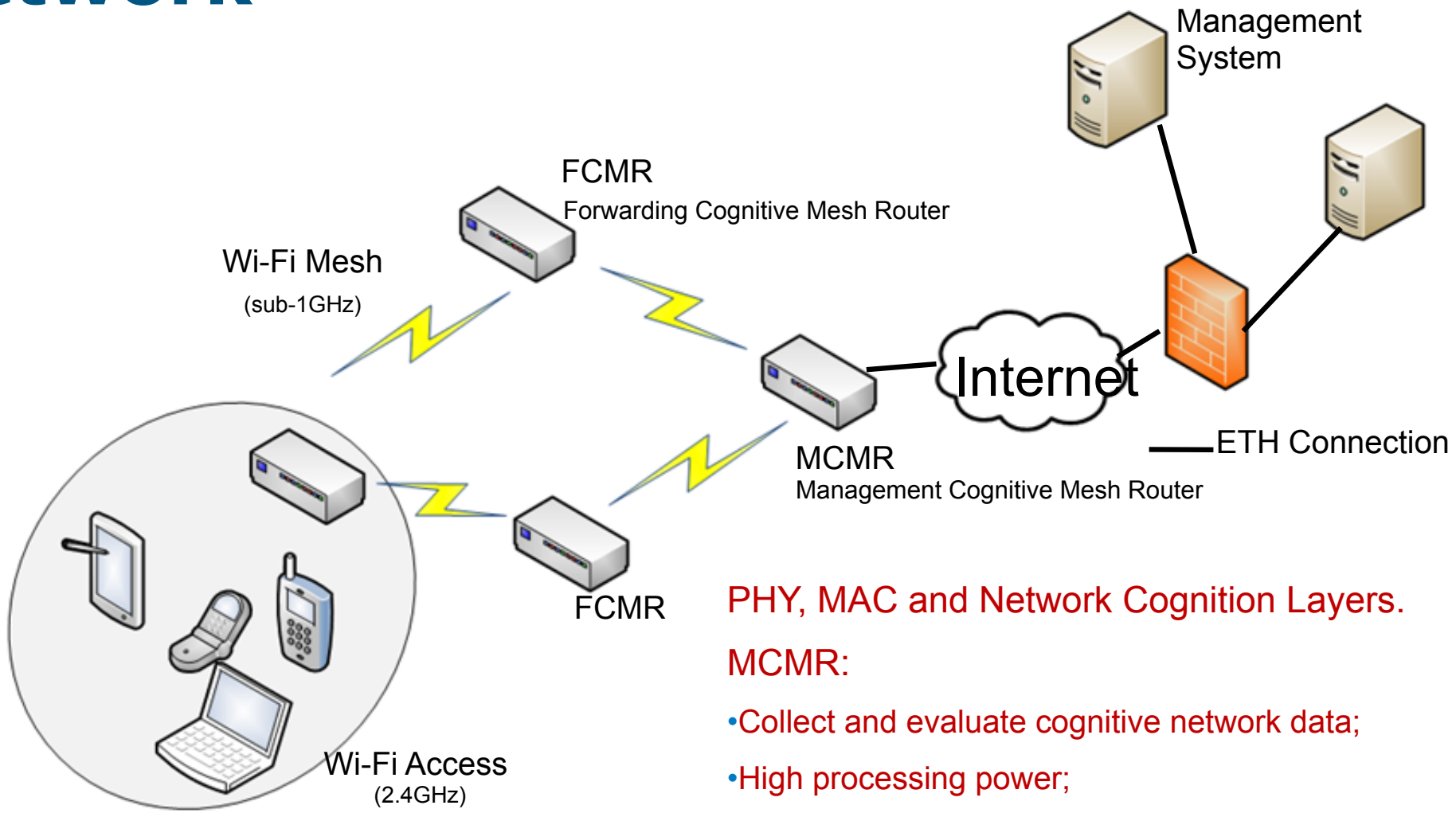
STEP 2: Getting metric to be used as trigger decision

1: **for** $i \in F, F \rightarrow Set\ of\ Channels$ **do**
2: $Q \leftarrow \frac{P_i}{Z_i}$
3: **end for**

STEP 3: Ranking channel update

1: **while** $Q \neq 0$ **do**
2: $C \leftarrow descendingOrder(Q)$
3: $i^* \leftarrow C[0]$
4: **if** $IsAlive = 0$ **then**
5: *switch to channel* i^*
6: **if** $IsAlive = 0$ **then**
7: $i^{**} \leftarrow C[1]$
8: *switch to channel* i^{**}
9: **end if**
10: **end if**
11: **end while**

CCMN – CPqD Cognitive Mesh Network



PHY, MAC and Network Cognition Layers.

MCMR:

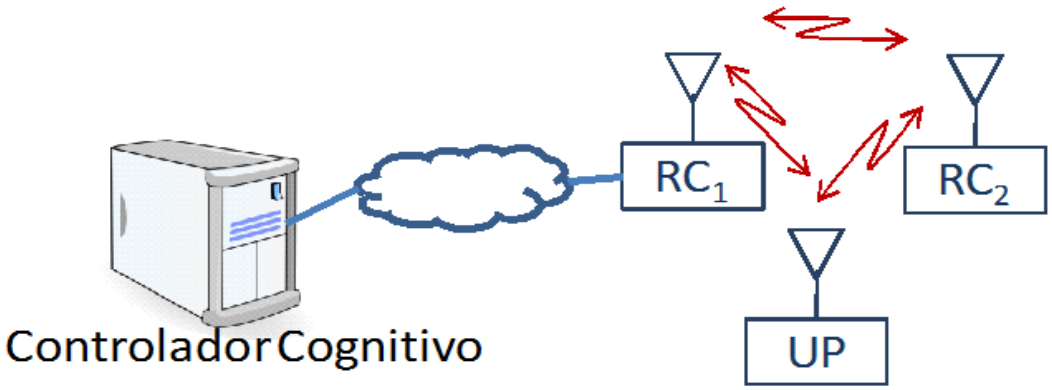
- Collect and evaluate cognitive network data;
- High processing power;
- Evaluate non-time critical algorithms;
- Evaluate complex cognitive procedures.

Cognitive Network at CPqD (prototypes)

Cognitive Radio Prototype (2nd Generation)

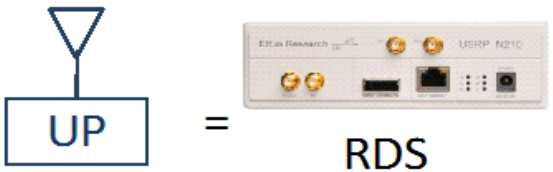
Mesh Router transferred to the industry (1st Generation)

Elements of the Cognitive Network at CPqD



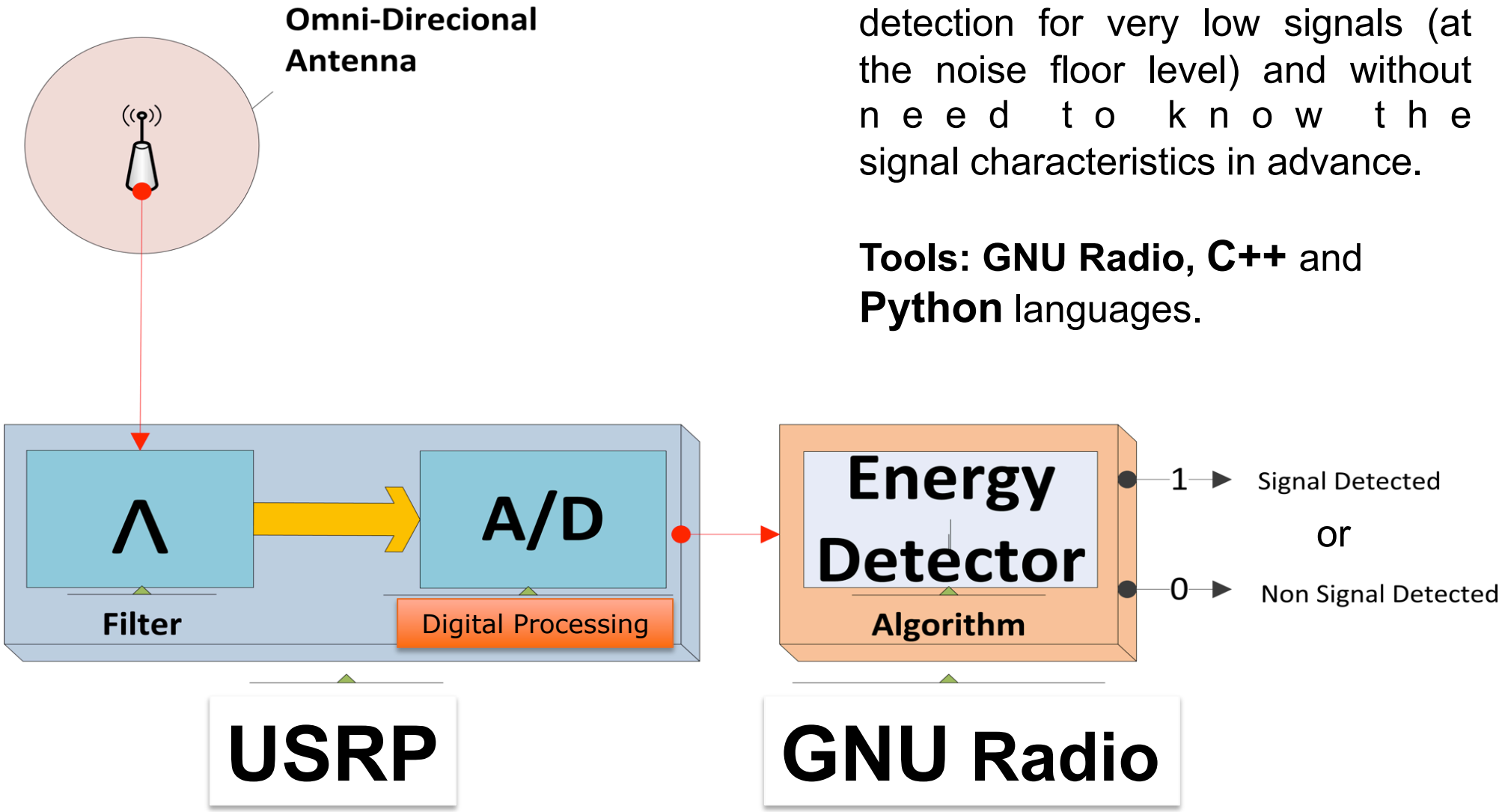
- Channel occupation data base.
- Best channel ranking.

- Mesh Router with spectrum sensing capability to detect signals with SNR > 1 dB



- Primary User with OFDM Signal with BW = 5MHz

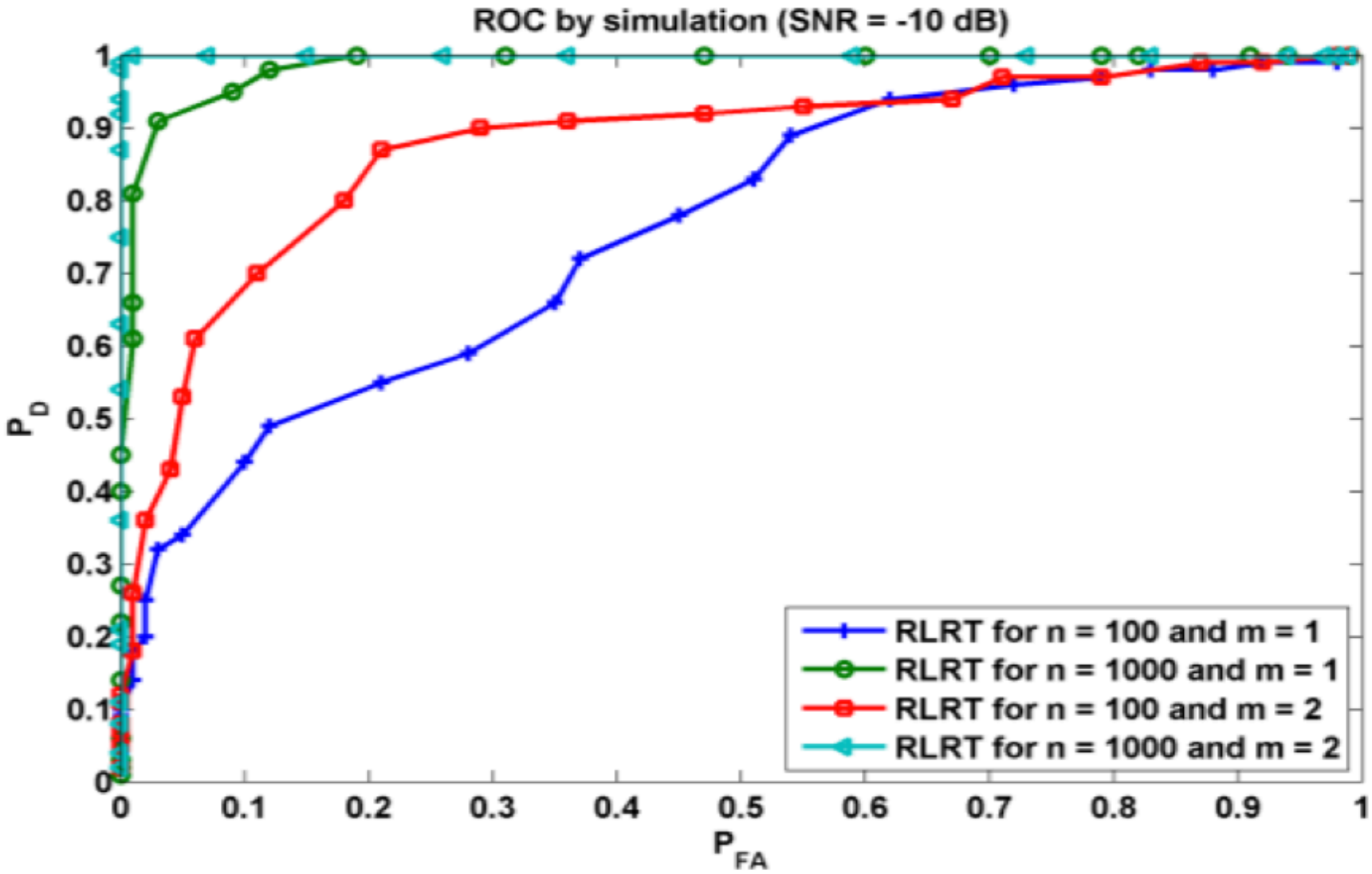
Generic sensing algorithm



Main Objective: Spectrum energy detection for very low signals (at the noise floor level) and without need to know the signal characteristics in advance.

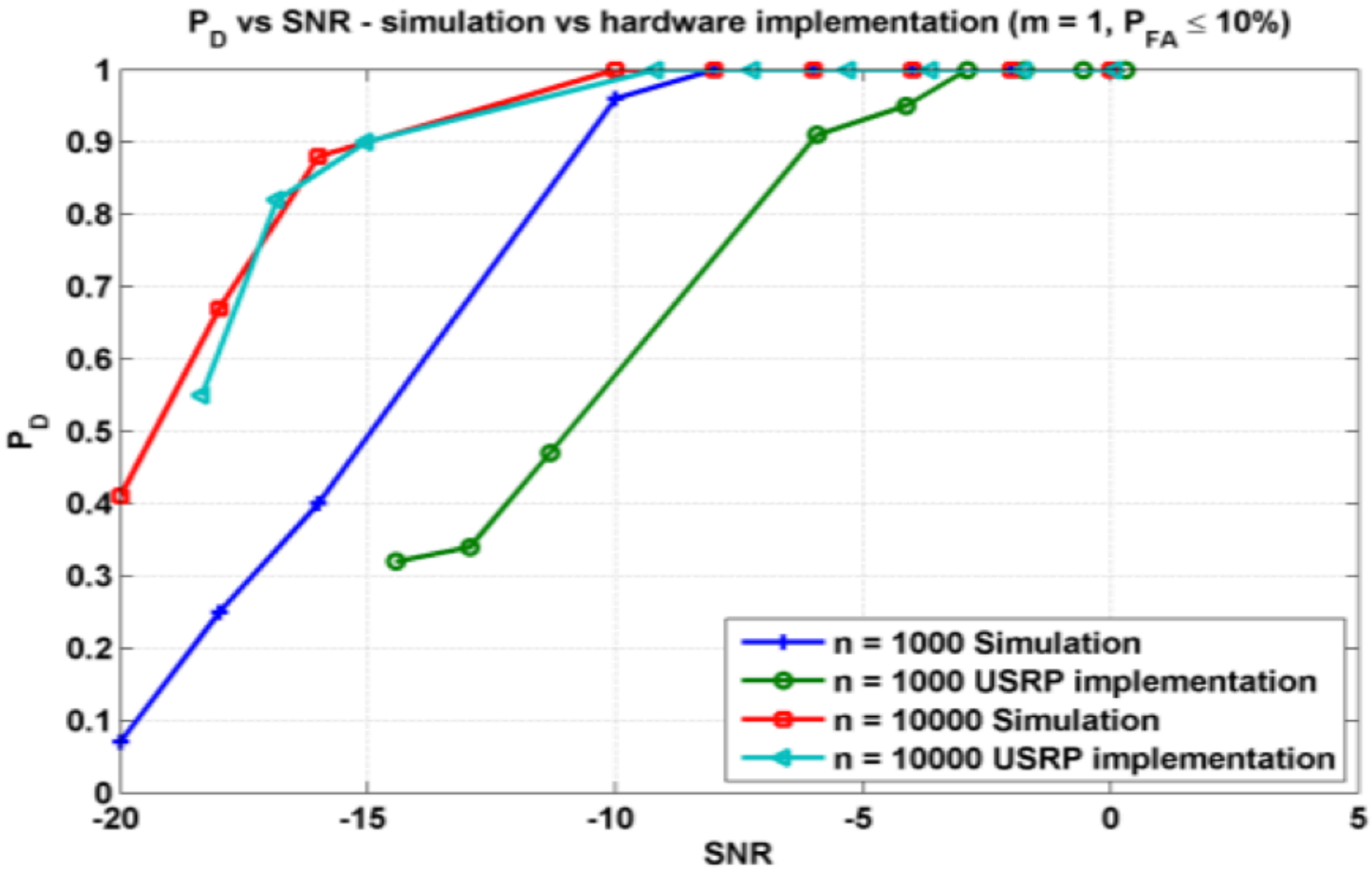
Tools: GNU Radio, C++ and **Python** languages.

Performance of primary user detection



* A USRP-based scheme for cooperative sensing networks – 2013 research paper at CPqD

Performance of primary user detection



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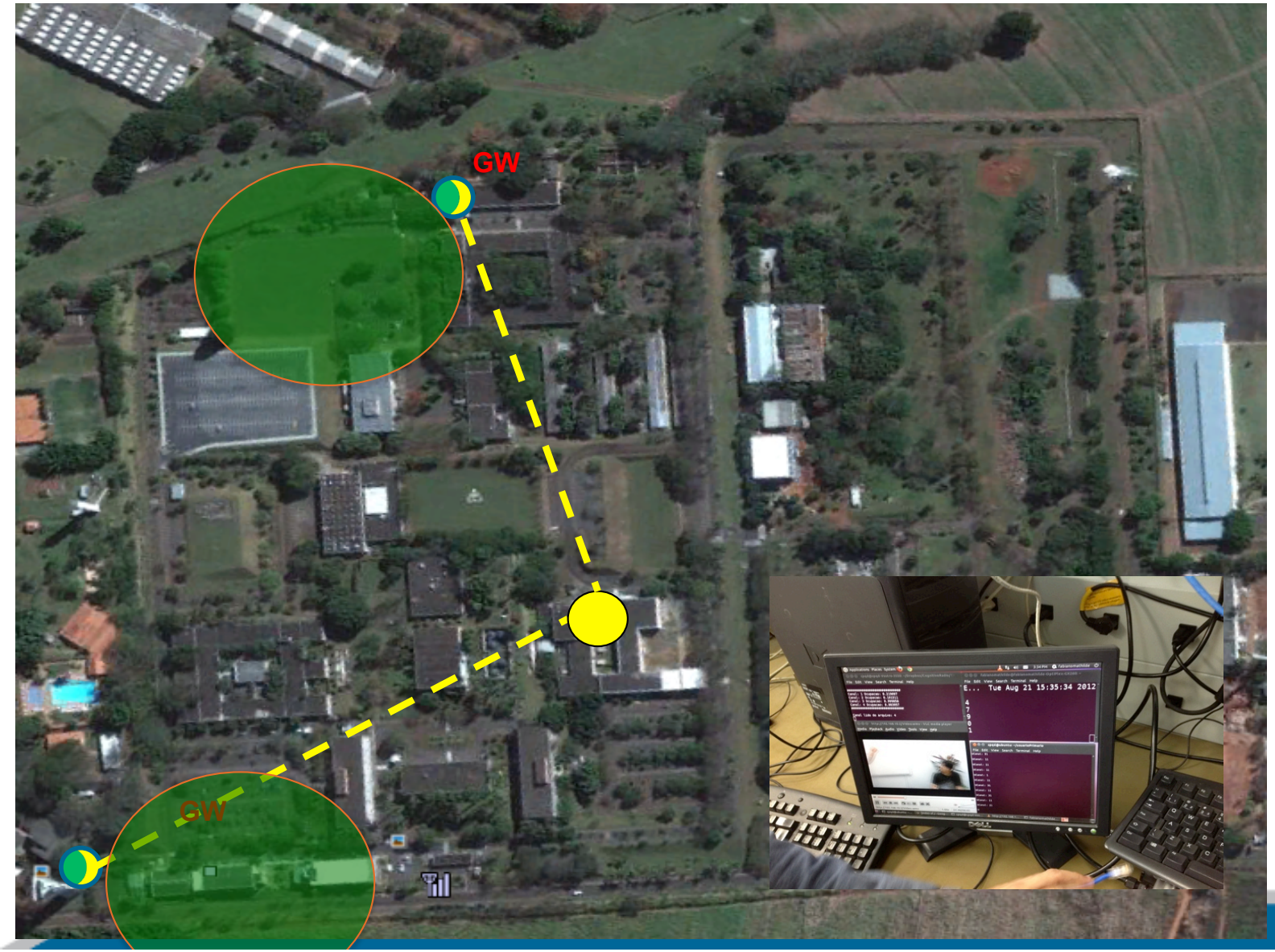
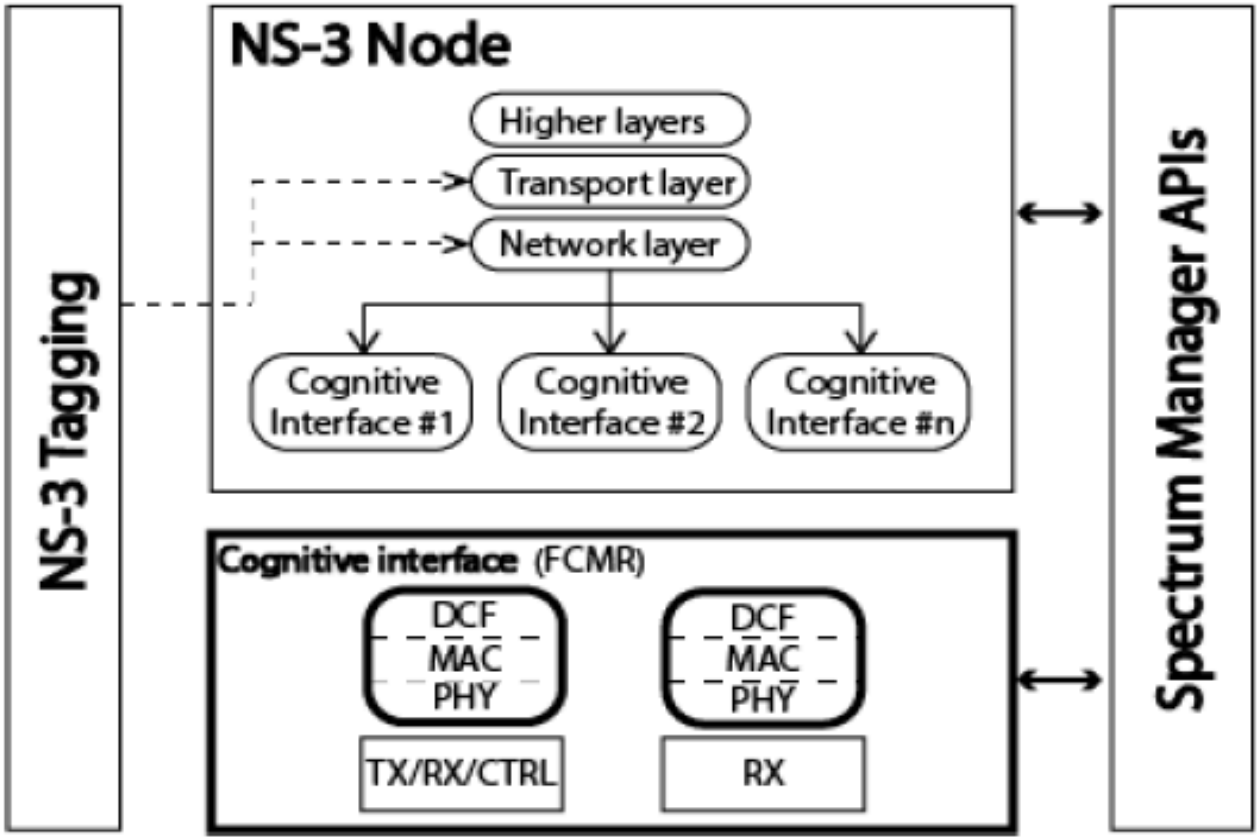
Real cognitive network at CPqD Campus



- Sub-1GHz(with cognition)
- 2.4GHz/Sub-1GHz) IEEE 802.11n

NS-3 SIMULATOR MODEL FOR CCMN



A. Al-Ali, and K. Chowdhury, “Simulating dynamic spectrum access using ns-3 for wireless networks in smart environments.” in Sensing, Communication, and Networking Workshops (SECON Workshops), 2014 Eleventh Annual IEEE International Conference on, 2014, pp. 28-33.

Advantages to use NS-3 over implementation in real scenario.

- Non limitation in topology scenario.
- It could be implemented as many mesh routers based on user requirements.
- Advantages to test other new algorithms in a variety of scenarios.
- Posibility to apply the same algorithms in other air interfaces technologies as LTE because ns-3 supports LTE.

Average throughput with TCP traffic using MC-OIM algorithm

Average Throughput [Mbps]		Primary User type	Throughput Gain [%]
with MC-OIM	without MC-OIM		
6	6	Without PU and without cognition	
5.23	4.83	Without PU	8.28%
4.94	4.43	Random PU	11.5%
4.83	3.73	Sequential PU	29.5%
5.5	4.1	Sequential PU simulated in ns-3	34%

Conclusions

- Tests performed using the MC-OIM algorithm showed in all cases a greater throughput compared to tests performed without using algorithm MC-OIM.
- Validation of ns-3 simulation was done using real implementation as a reference with similar results.
- This ns-3 extension could be used to test bigger scenarios without the necessity of extra expenses in building real scenario setups.

спасибо

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