



Overview of the CREW project

How CREW can facilitate the development of complex wireless systems?

Ingrid Moerman - iMinds



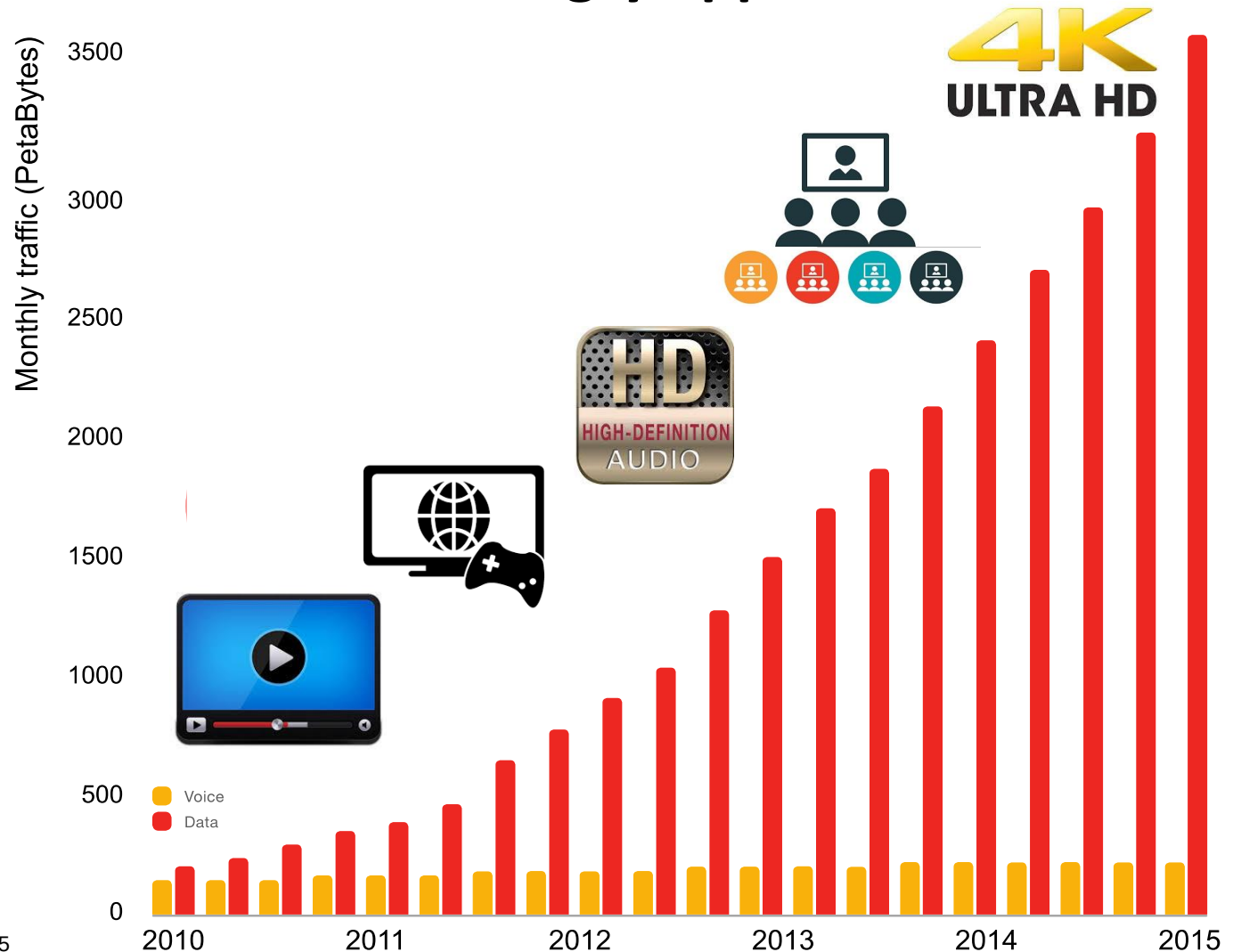
The research leading to these results has received funding from the European Union's Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 258301 (CREW project).



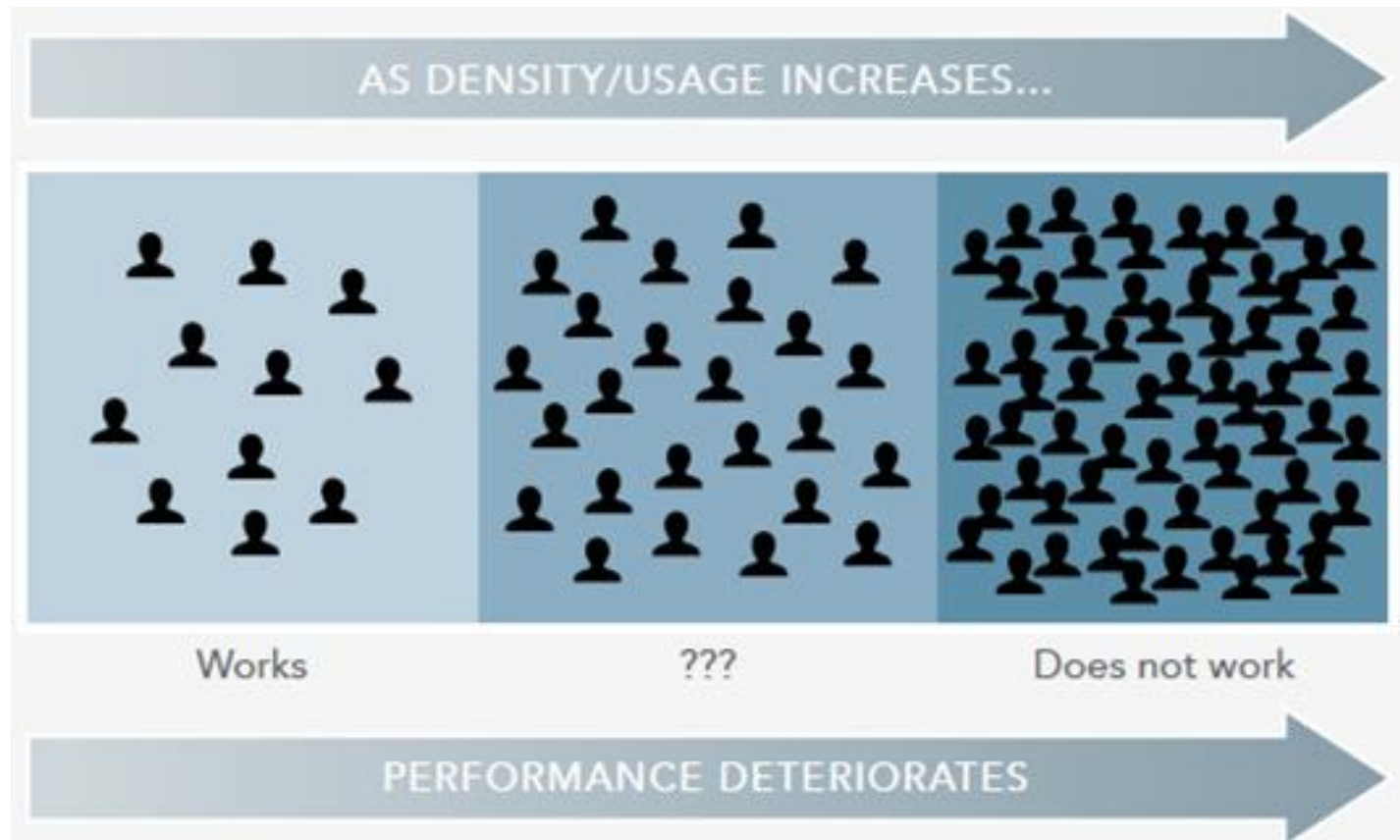
■ Homogeneous → heterogeneous technologies



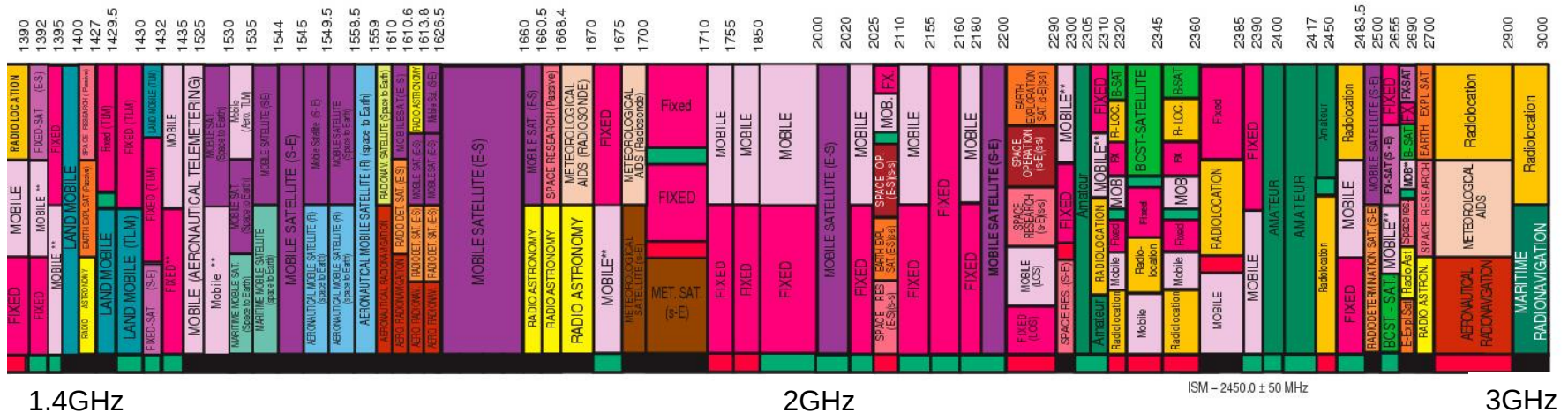
- Homogeneous → heterogeneous technologies
- Low data rate → bandwidth hungry applications



- Homogeneous → heterogeneous technologies
- Low data rate → bandwidth hungry applications
- Low → high density of devices



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- Low data rate → bandwidth hungry applications
- Low → high density of devices
- Low → high spectrum occupancy
 - overcrowded unlicensed bands
 - underutilized licensed bands



- Homogeneous → heterogeneous technologies
- Low data rate → bandwidth hungry applications
- Low → high density of devices
- Low → high spectrum occupancy
 - overcrowded unlicensed bands
 - underutilized licensed bands
- No/low interference
 - high interference

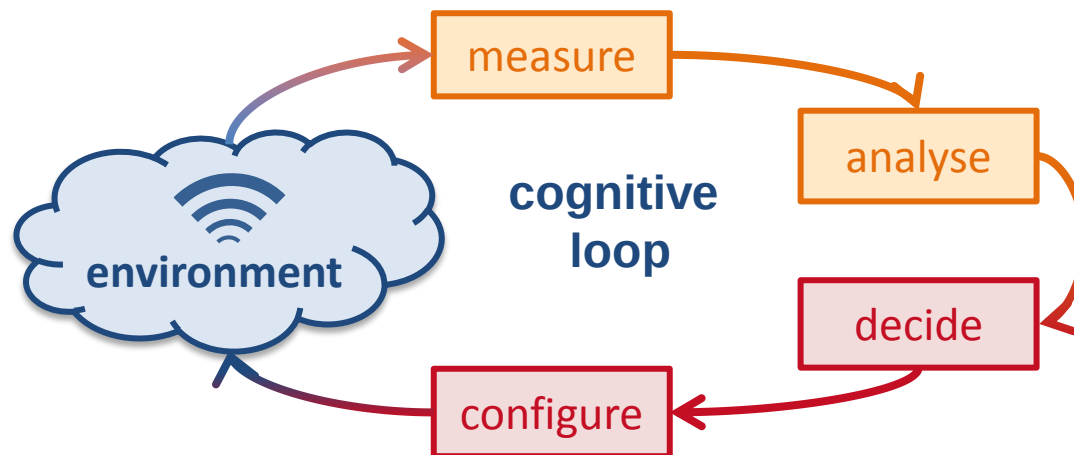


■ Main research questions?

How to efficiently use the available resources (spectrum, energy)?

How to measure the available resources?

How to adapt the radios (transmitters and receivers) and networks to the wireless environment and the user needs?



Theoretical analysis

- PHY layer & link level analysis
- Network analysis
 - ideal wireless environment
 - simplified link models

Simulations

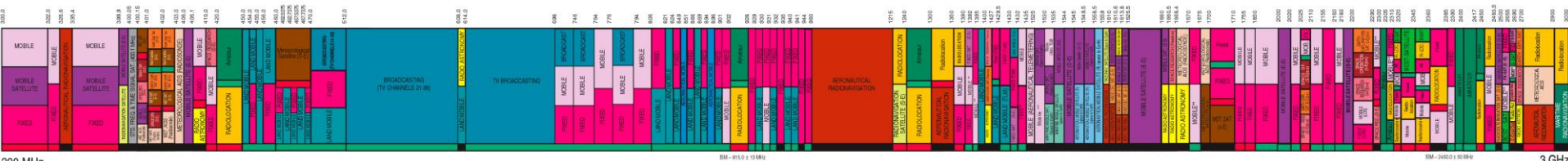
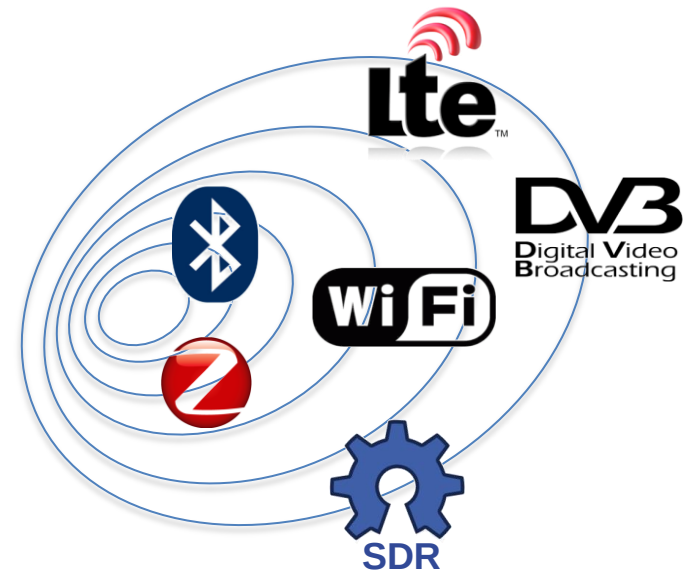
- Large-scale validation possible, BUT under oversimplified, unrealistic wireless conditions
- Interference, spectrum sensing and hardware characteristics hard to simulate

Experimental validation

- Realistic wireless environment, BUT
 - using HW is difficult
 - HW is expensive → small-scale experiments
 - experiments are hard to configure
 - experiments are often not replicable



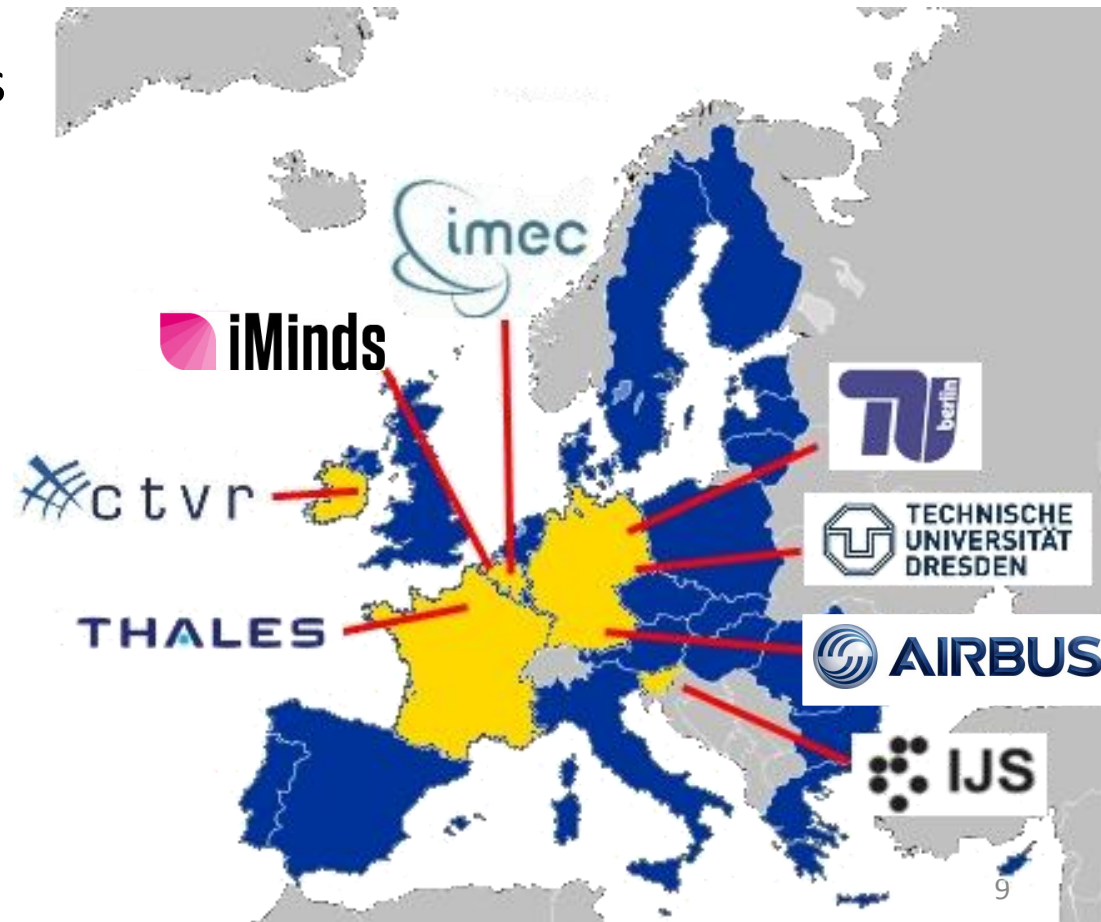
- advanced spectrum sensing
- cognitive radio (CR)
- cognitive networking (CN)
- spectrum sharing in licensed and unlicensed bands



■ Cognitive Radio Experimentation World

- FP7 call 5 (FIRE - Future Internet Research and Experimentation Initiative)
- October 2010 – September 2015
- 8 core partners
- 3+6 open call partners

- UDUR (UK)
 - TUIL (DE)
 - TECNALIA (ES)
 - IT (PT)
 - CMSF (PT)
 - CNIT (IT)
 - WINGS (GR)
 - UTH (GR)
 - NICTA (AU)
- OC1
- OC2

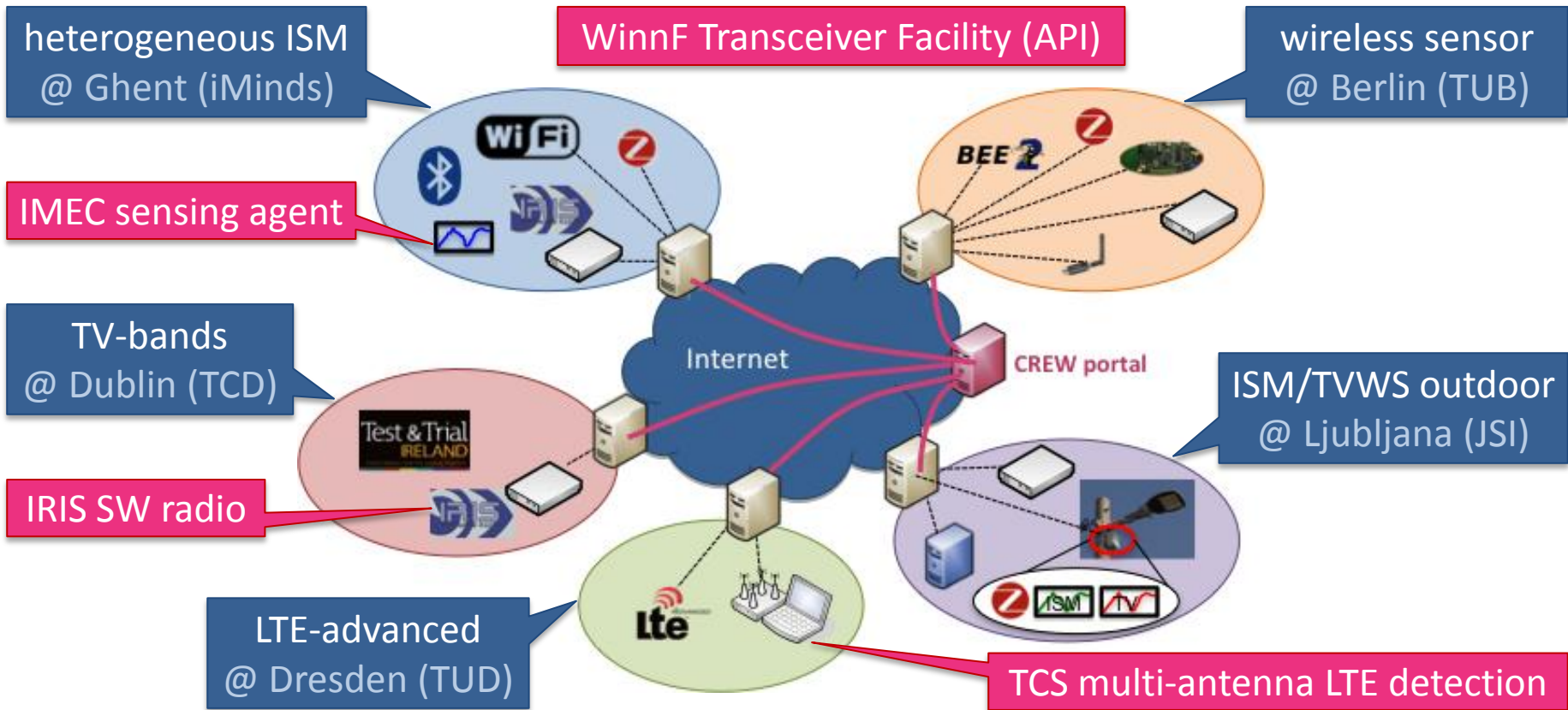


CREW is ...

- bringing together and open up testbeds for supporting research on spectrum sensing, cognitive radio & cognitive networking
- facilitating access to heterogeneous testbeds
- augment existing testbeds with novel cognitive components
- bringing together expertise on experimentation
- researching & offering better methodologies for experimentation (repeatability, reproducibility, comparability)

... in view of

- validating advanced cognitive solutions (new concepts & algorithms) using CREW testbeds and CREW methodologies

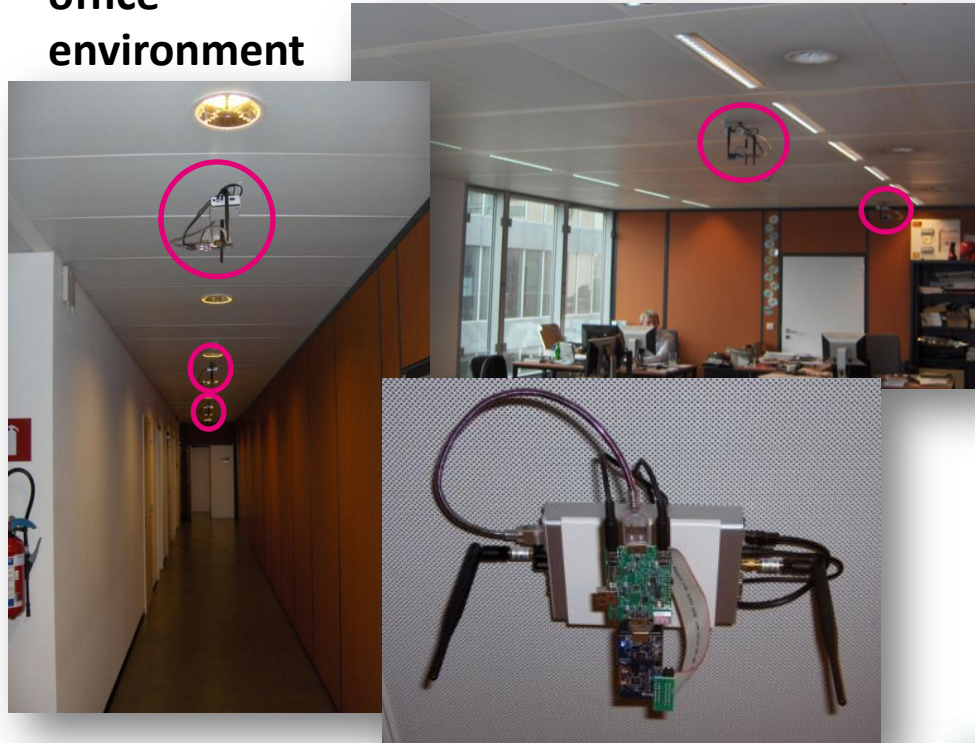


	IEEE 802.11		IRIS GPP-based software radio platform		IMEC Sensing Agent
	IEEE 802.15.1		Comreg spectrum licenses		UHF/VHF TV Sensing
	IEEE 802.15.4		BEE 2 FPGA platform		ISM Bands Sensing
	LTE-advanced		USRP Software Radio		TCS Multi-antenna LTE detection
	Eyes I FX nodes		VESNA platform on light pole		WiSpy Spectrum Analyzer
	CREW Database				Interconnection of portals
					Interconn. between testbed elements

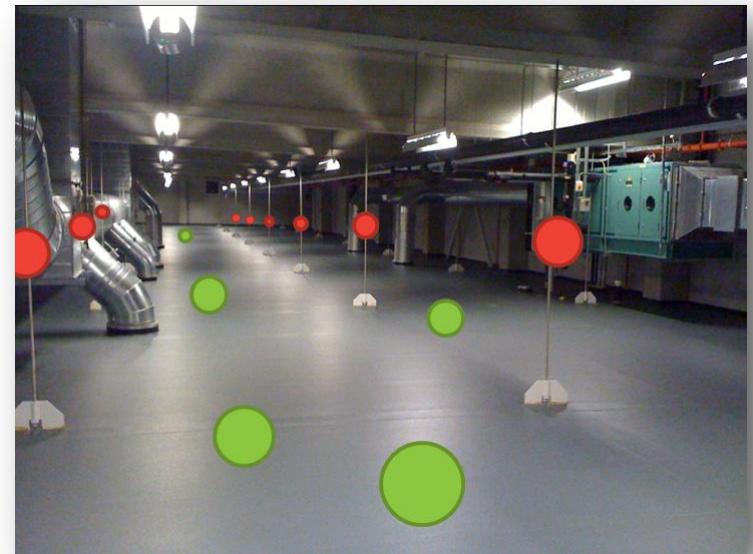


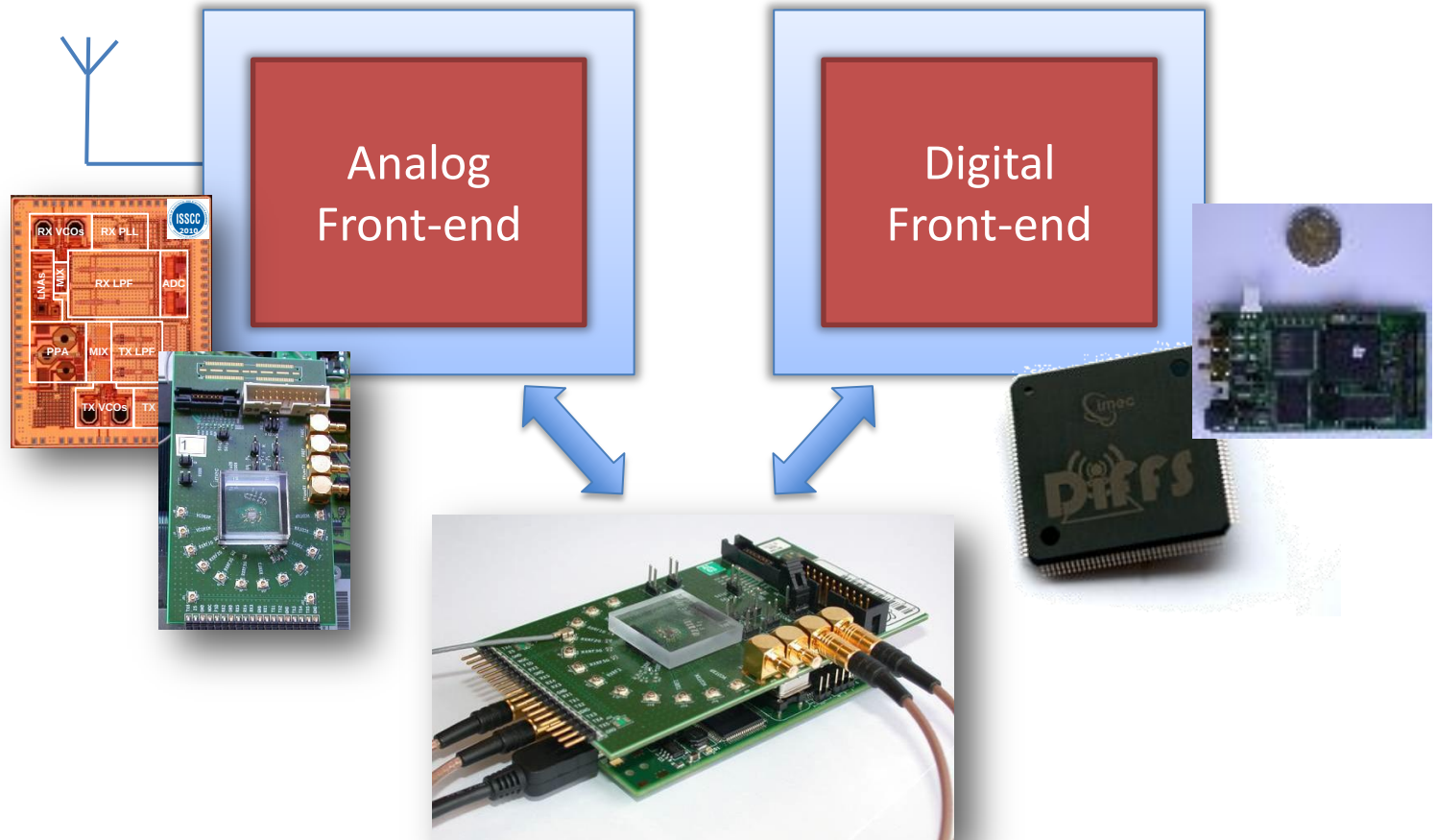
200 + 60 wireless nodes (WiFi/ZigBee/Bluetooth)
cognitive components: USRP, WARP, AirMagnet, IMEC sensing agent

office
environment



Zwijnaarde environment





Advanced spectrum sensing
Combination of analog & digital FE in compact device



**204 + 16 wireless sensor nodes (Tmote Sky/EyesIFXv2/Shimmer2)
cognitive components: Wi-Spy, BEE 2 FPGA platform**



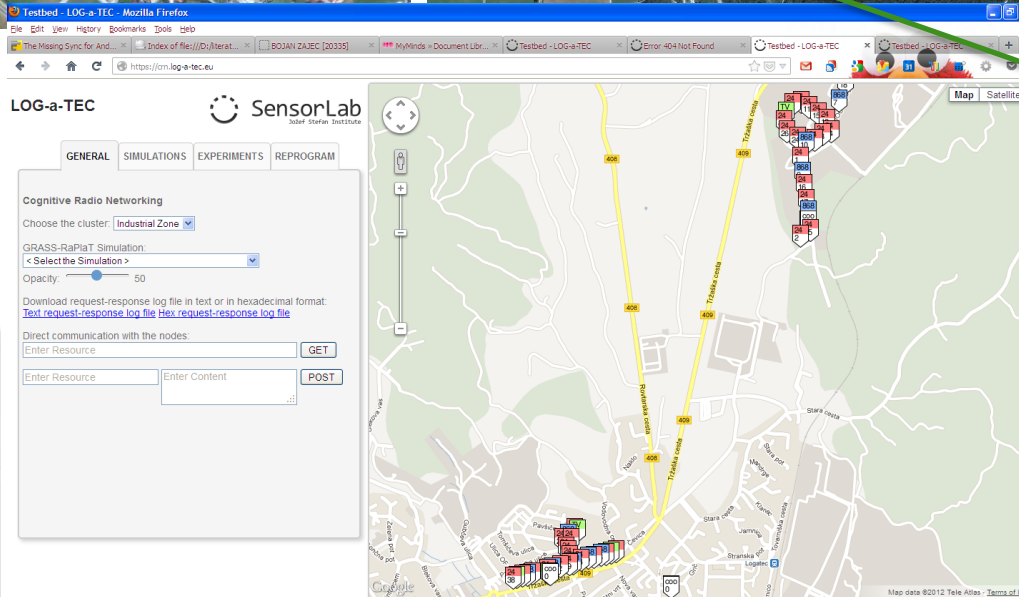
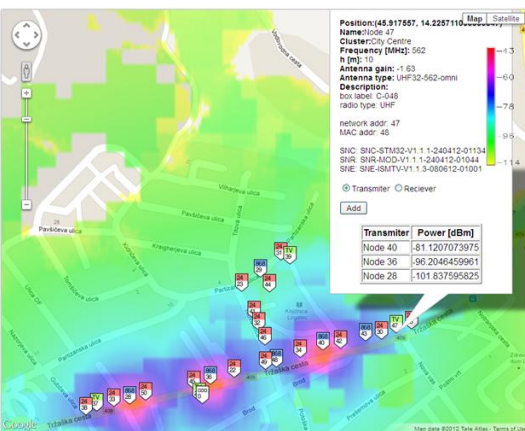
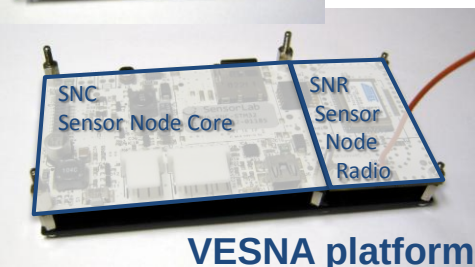
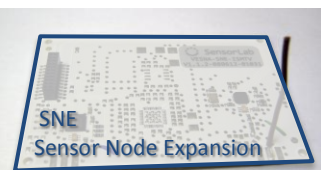
TRINITY
COLLEGE
DUBLIN



**25 IRIS reconfigurable cognitive radio platforms + 25 USRP
TV-bands license**



Signalion SORBAS (3 eNodeB + 3 UE)
Signalion HALO 430 SDR equipment
Indoor & outdoor
LTE license

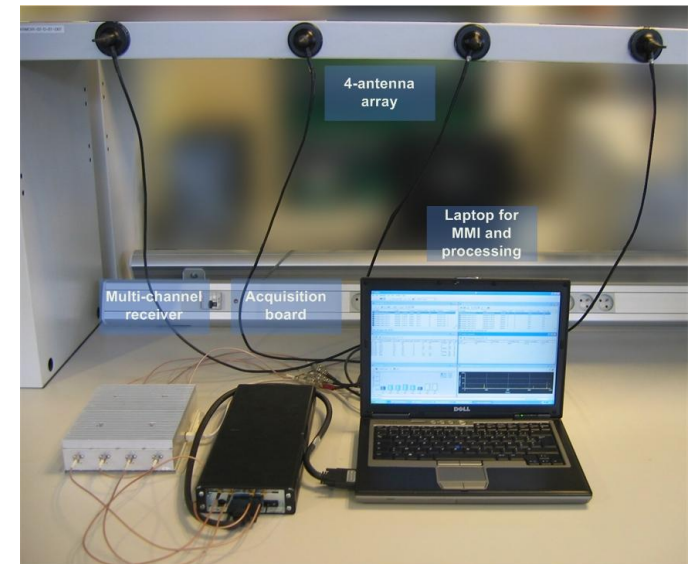
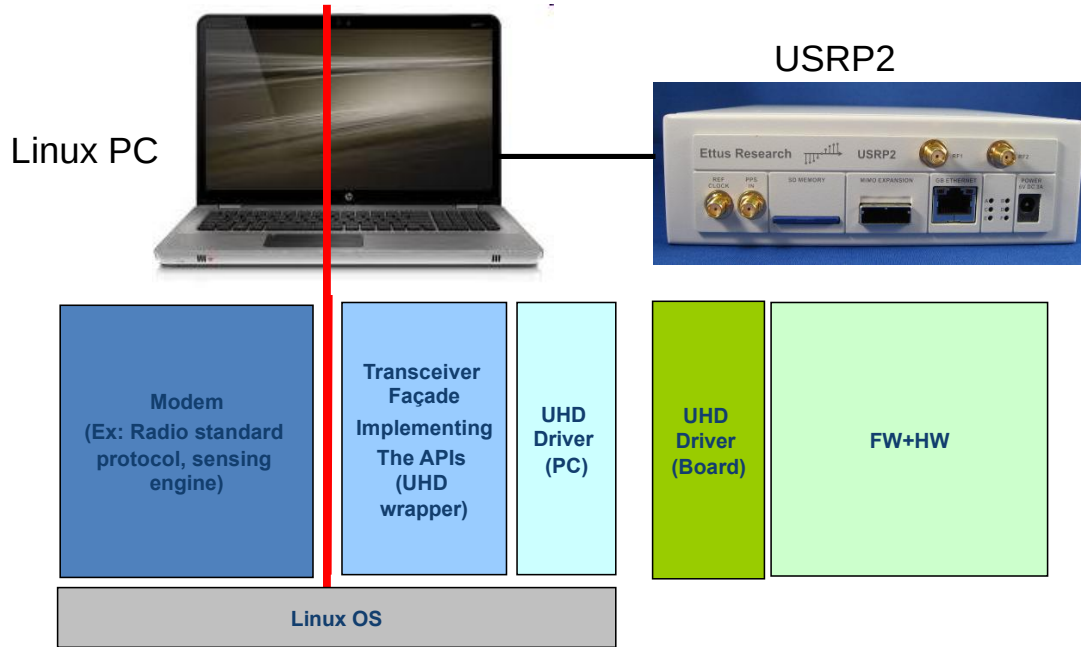


53 outdoor VESNA sensor nodes

- ISM 868 MHz, ISM 2.4 GHz & UHF TV bands

GRASS RaPlaT open source radio-planning tool

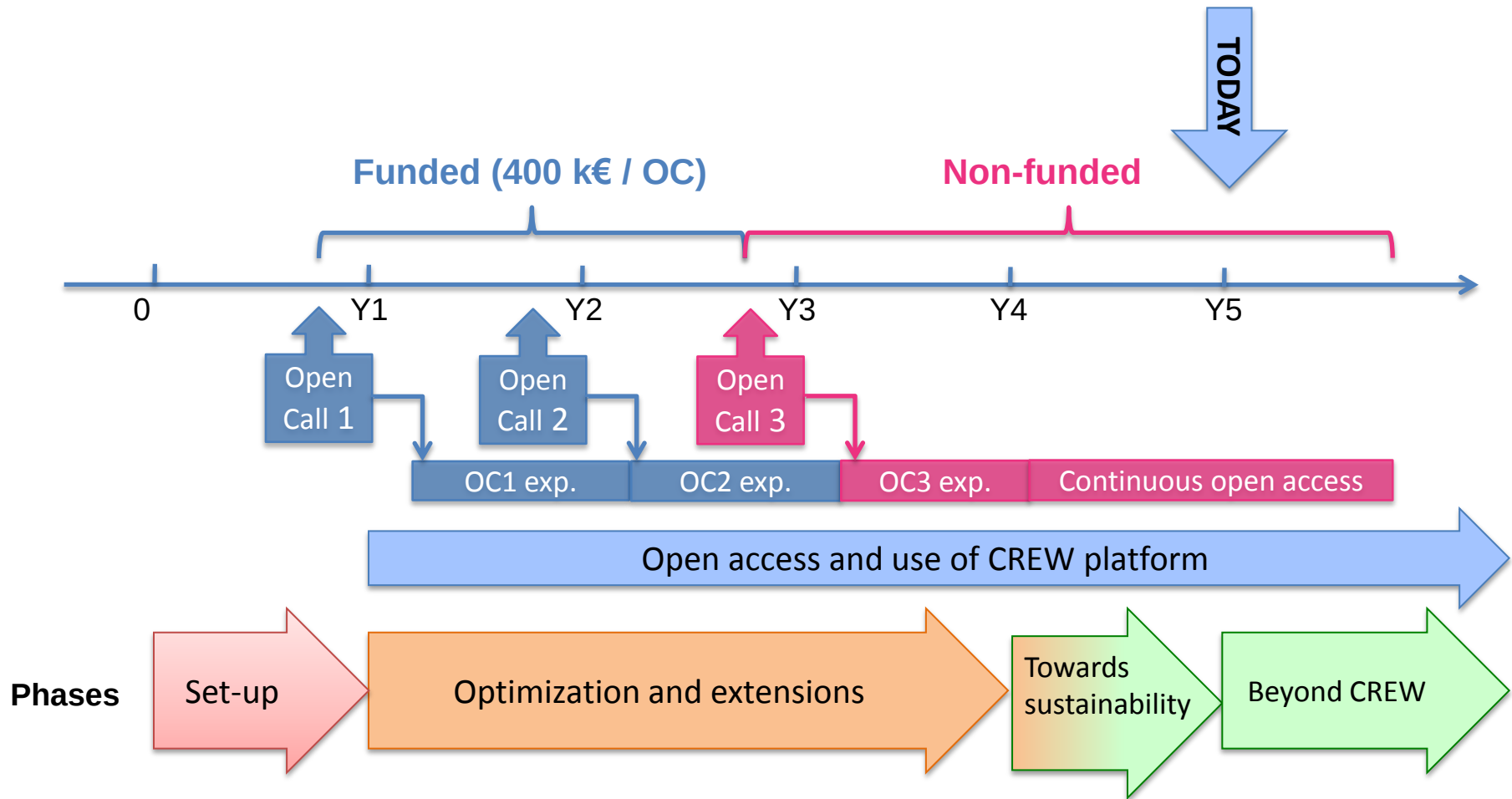
THALES

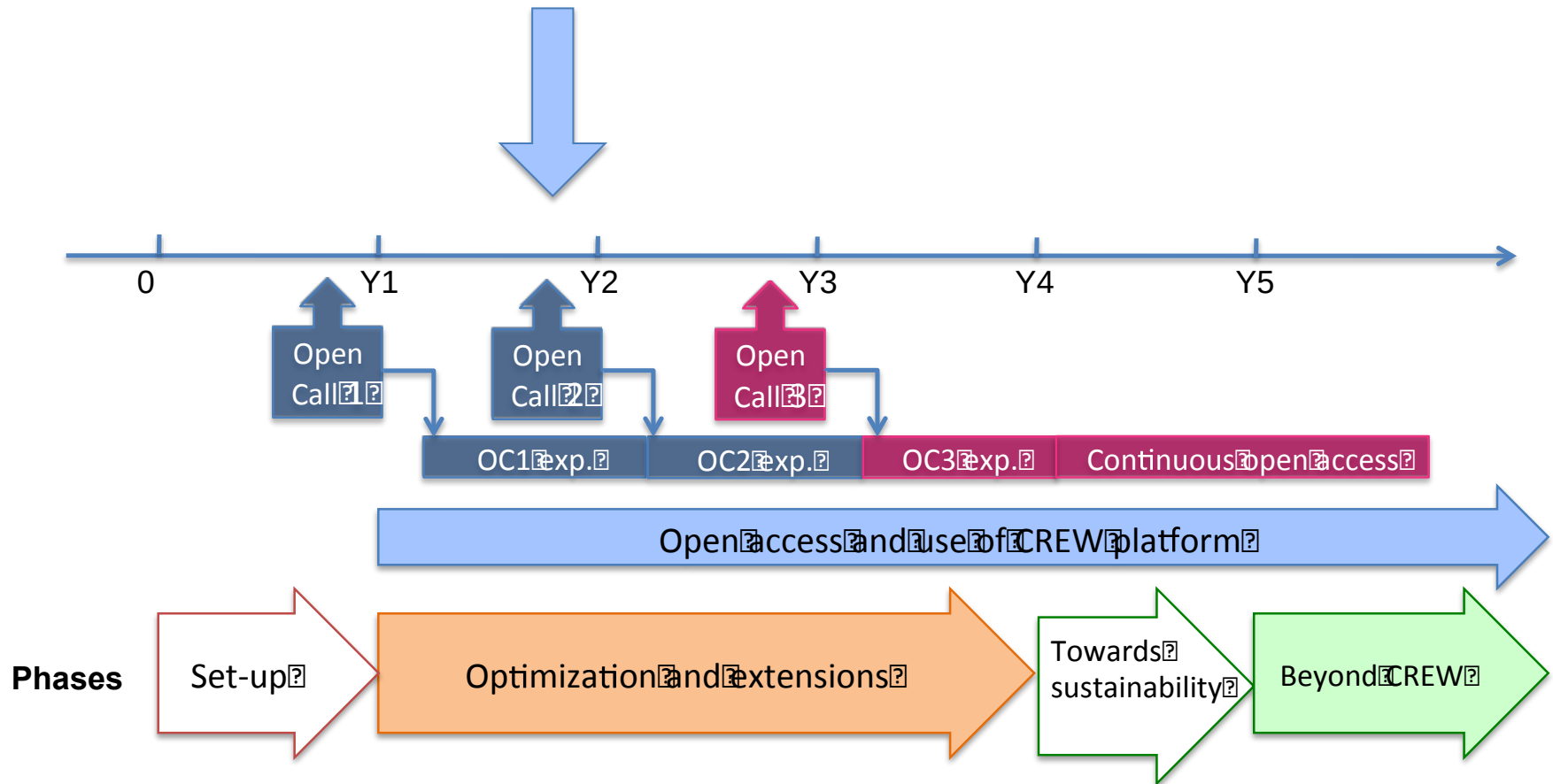


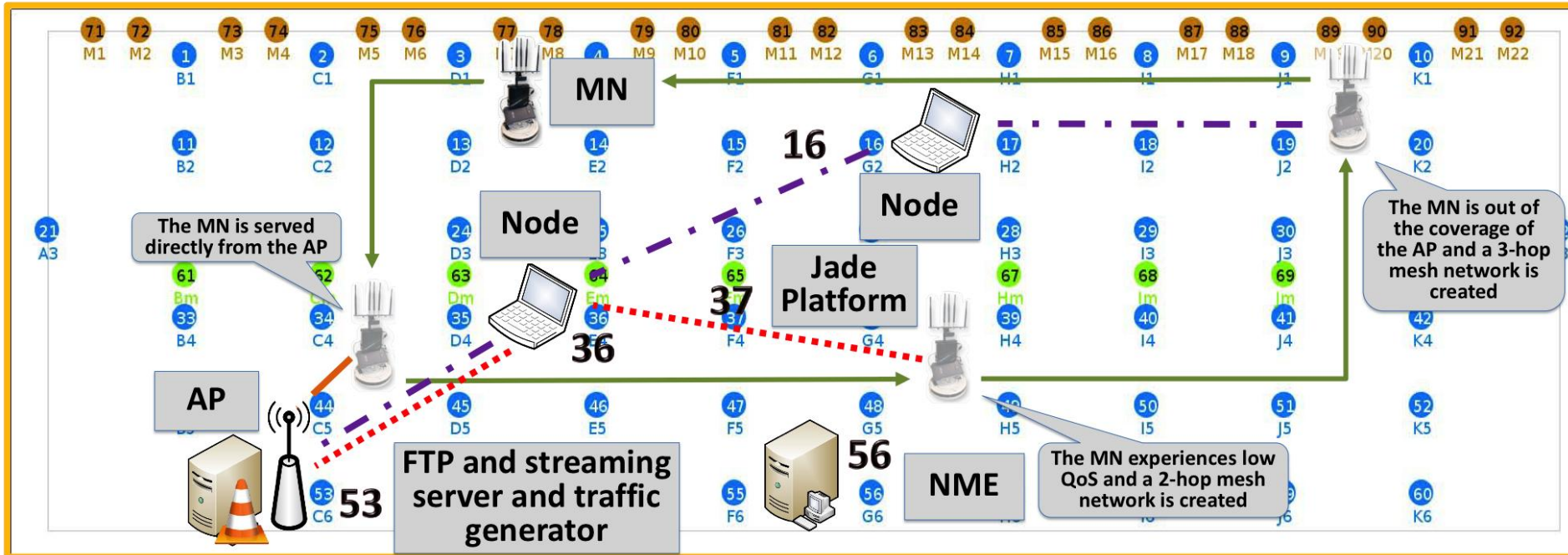
Transceiver API for SDR architecture (compliant to WINNF)
Multi-antenna LTE detection



Mock up of airplane





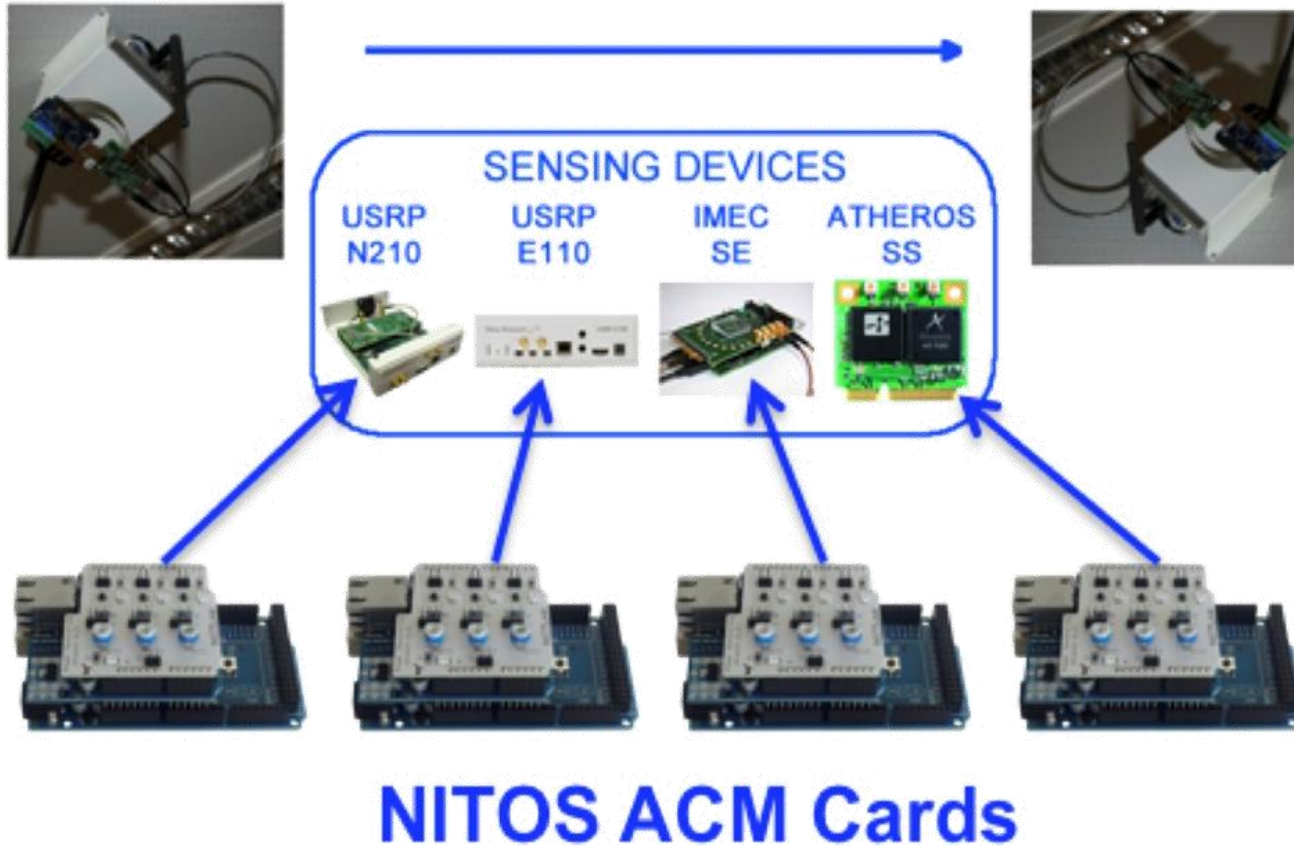


Problem: mobile node loses connectivity → low QoS
Solution: wireless mesh serving network + control channel

Online Monitoring of Spectrum Sensing Delay and Energy Consumption in the CREW Benchmarking Framework

Transmitter Wi-Fi Node

Receiver Wi-Fi Node



Integration of NITOS advanced CM card with the iMinds' w-ilab.t Testbed Architecture

Coexistence of microphones and TV broadcast using geo-location database & spectrum monitoring

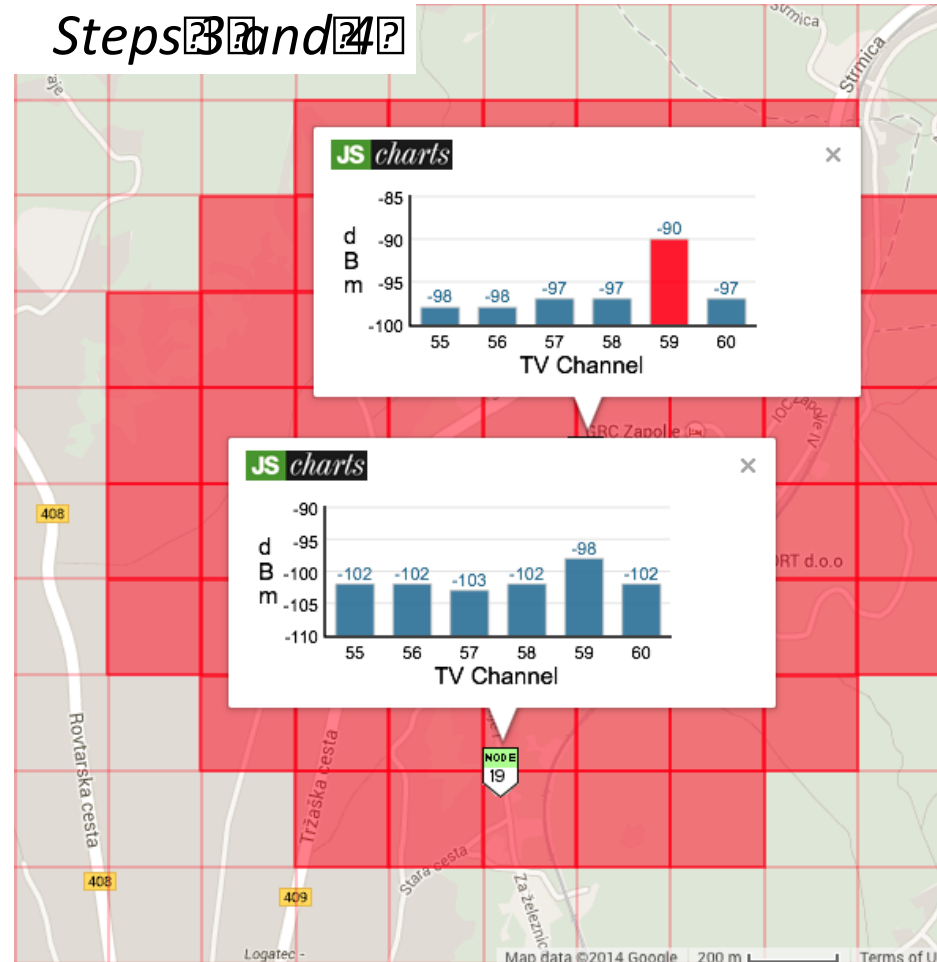
Step 1



Step 2



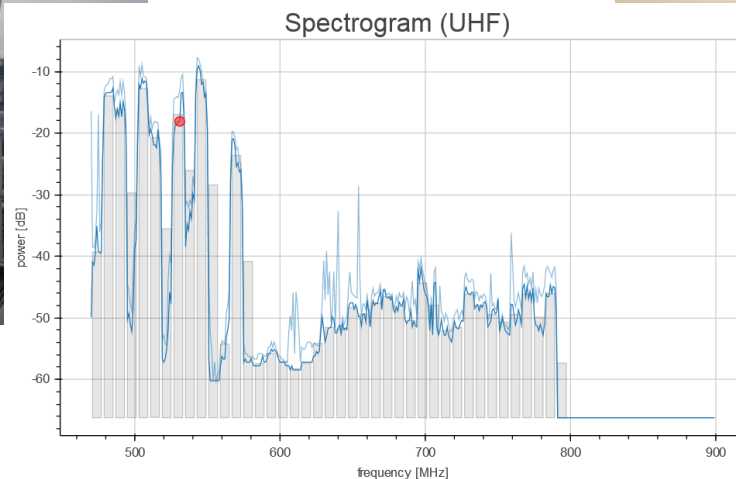
Steps 3 and 4



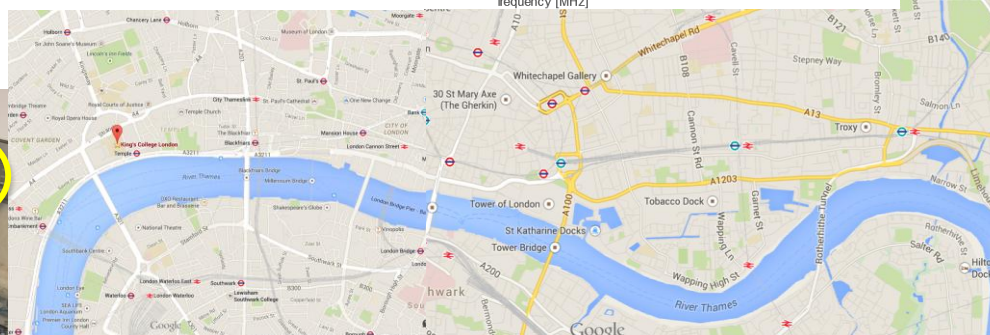
UHF spectrum sensing in Ofcom TVWS pilot



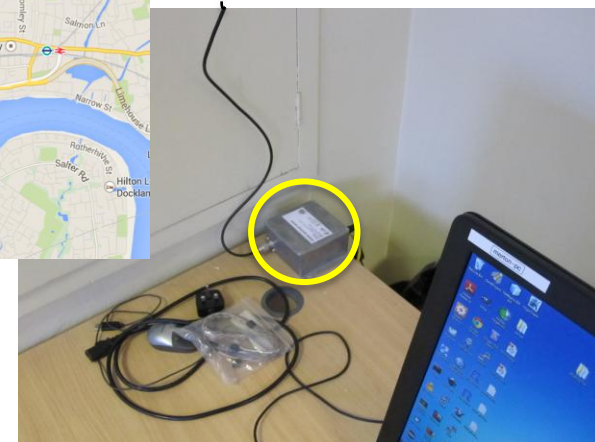
King's College London,
Strand



Queen Mary
University of London

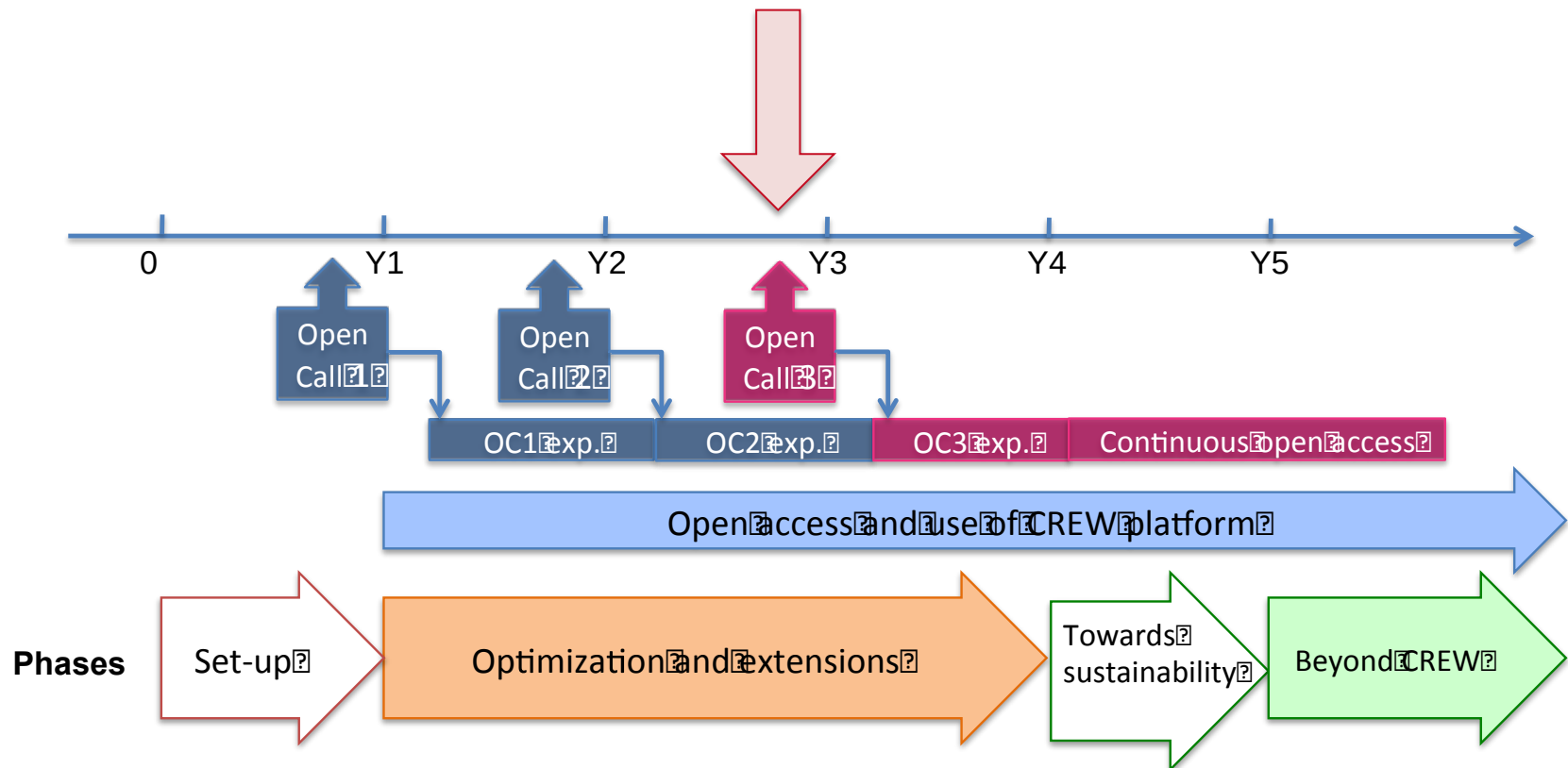


VESNA SNE-ESTHER



■ See presentation:

Daniele Lacamera (Altran): “How to develop and validate a scalable mesh routing solution for IEEE 802.15.4 sensor networks”





■ Open up wireless testbeds

- (diverse) tools for experimentation

■ Offer

- legacy + CR hardware
- methodologies for experimentation



• Fed4FIRE compliant wireless testbeds

- unified tools for experimentation
- fixed + portable testbeds

• Offer

- flexible radio hardware + software platforms
- radio and network control via UIs



• Intelligent wireless network control

- flexible hardware + intelligent software
- dense heterogeneous and small cell networks
- on-demand end-to-end wireless connectivity

What is Fed4FIRE?

Federation



Easy to use
Single account
Single tool
Common support

of

testbeds



Diverse devices
e.g software defined networking,
Cloud, bigdata, wireless, sensor



Testbeds in Fed4FIRE

● Wired ● Wireless ● Openflow ● Cloud ● Other

w-iLab.t

(iMinds) Zwijnaarde, Belgium

Virtual Wall

(iMinds) Gent, Belgium

OFELIA - Bristol

(UNIVBRIS) Bristol, Great Britain

IRIS

(TCD) Dublin, Ireland

Planetlab Europe

(UPMC) Paris, France

BonFIRE

(EPCC, Inria) Paris, France

Community Lab

(UPC) Spain

Smart Santander

(UC) Santander, Spain

FIONA

(Adele Robots) Lianera, Spain

OFELIA - i2CAT island

(i2CAT) Barcelona, Spain

10G GRACE TESTER

(UAM) Madrid, Spain

Perform LTE

(UMA) Malaga, Spain

Outside EU

NORBIT

(NICTA) Sydney, Australia

KOREN

(NIA) Seoul, Korea

Ultra Access

(UC3M) Stanford, USA

Tengu

(iMinds) Brussels, Belgium

PL-LAB

(PSNC) Warsaw, Poland

FuSeCo

(FOKUS) Berlin, Germany

LOG-a-TEC

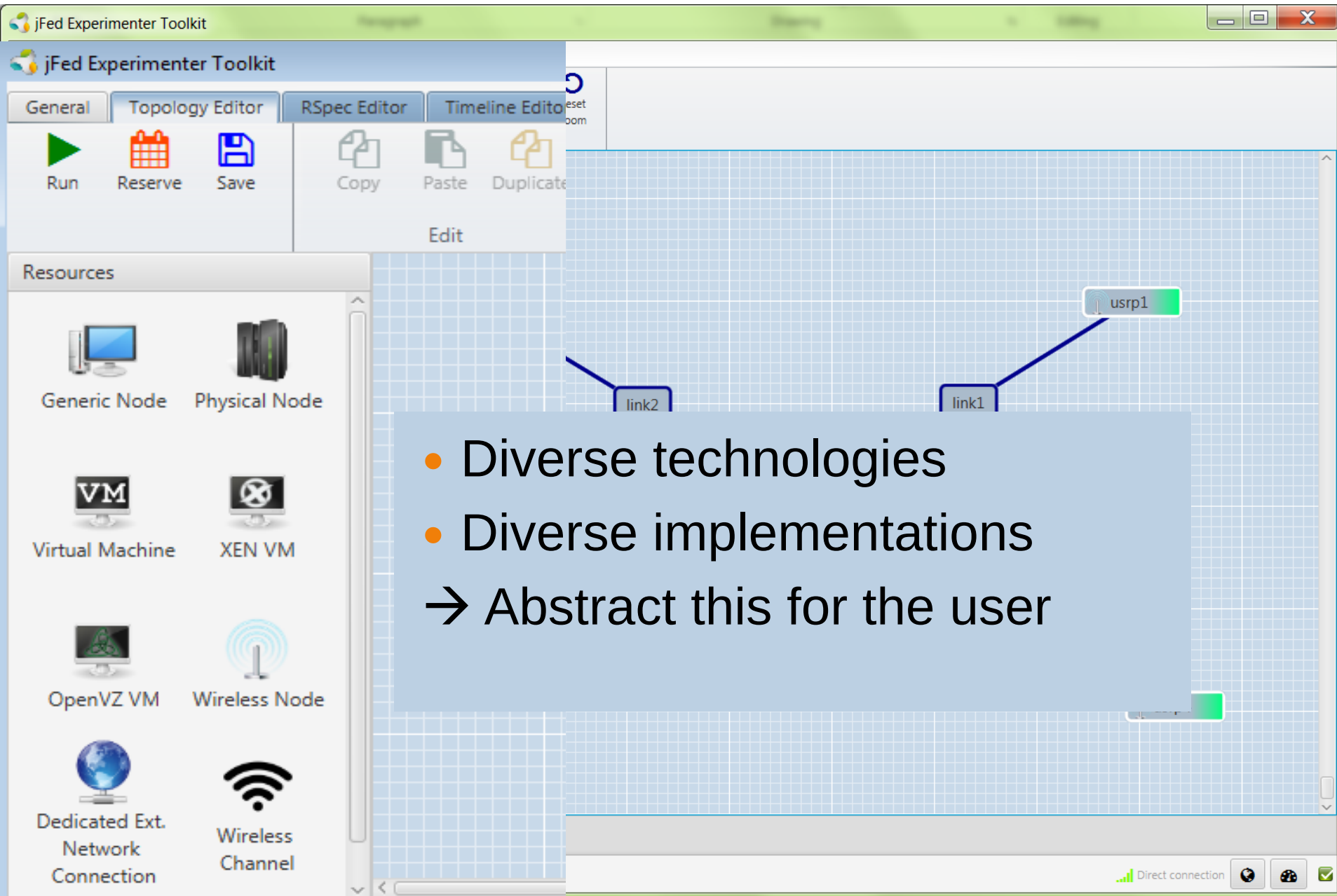
(JSI) Ljubljana, Slovenia

NETMODE

(NTUA) Athens, Greece

NITOS

(UTH) Volos, Greece



The image shows the jFed Experimenter Toolkit interface. It features a top menu bar with tabs for General, Topology Editor, RSpec Editor, and Timeline Editor. Below the menu bar are icons for Run, Reserve, Save, Copy, Paste, and Duplicate. A Resources panel on the left lists various components: Generic Node, Physical Node, Virtual Machine, XEN VM, OpenVZ VM, Wireless Node, Dedicated Ext. Network Connection, and Wireless Channel. The main workspace displays a network topology diagram on a grid background, showing a node labeled 'usrp1' connected to two links, 'link1' and 'link2'.

jFed Experimenter Toolkit

General Topology Editor RSpec Editor Timeline Editor

Run Reserve Save Copy Paste Duplicate

Edit

Resources

- Generic Node
- Physical Node
- Virtual Machine
- XEN VM
- OpenVZ VM
- Wireless Node
- Dedicated Ext. Network Connection
- Wireless Channel

usrp1

link1

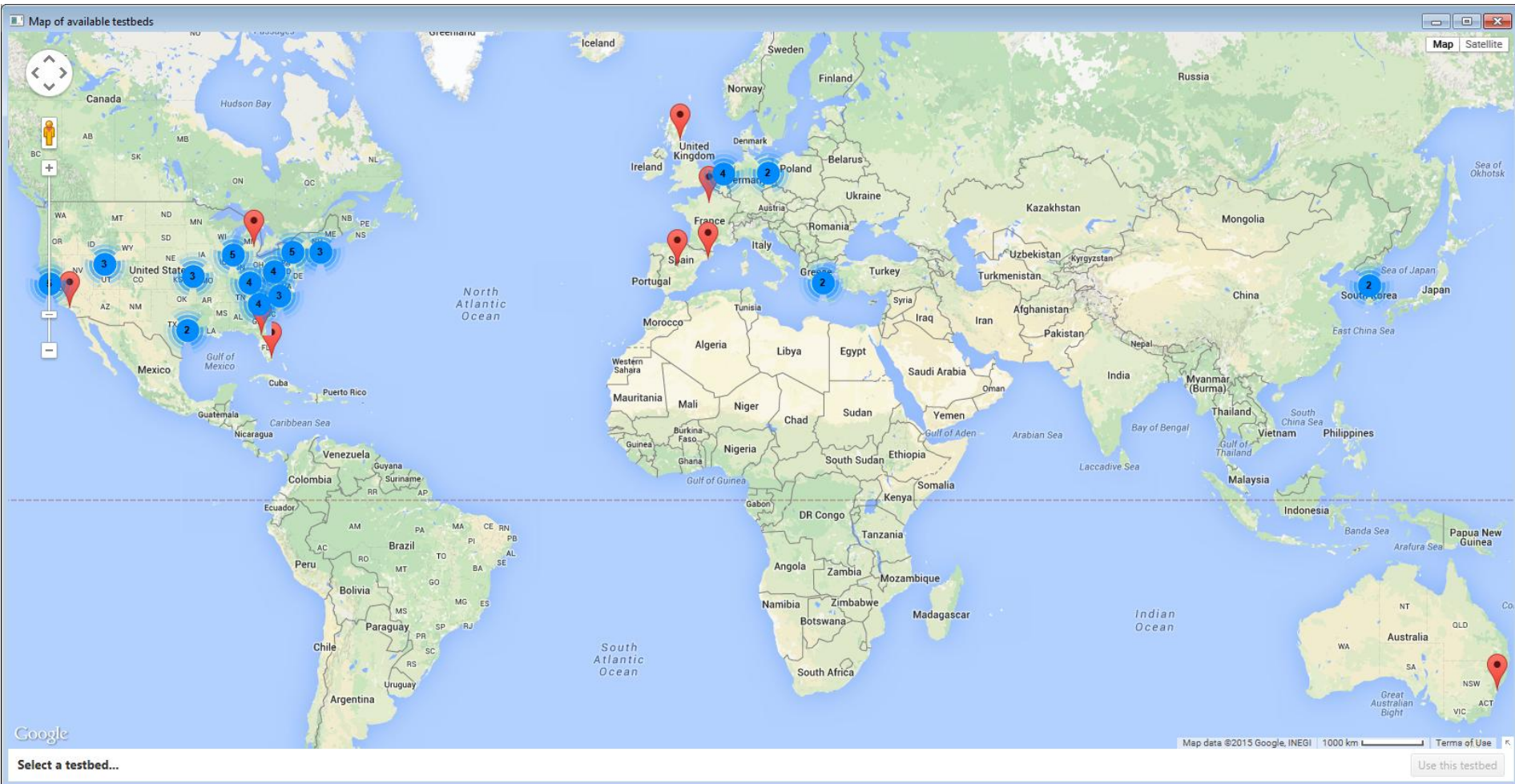
link2

- Diverse technologies
- Diverse implementations

→ Abstract this for the user

Direct connection

Accessible testbeds: single tool and account



3

Open Call 1

4

Open Call 2

7

Open Call 3

>20

Open Access

94

Peer reviewed
papers

9

Awards

62%

external use

19

Journal papers

33%

experiments
related to CREW

70%

academic use

20%

industrial use

10%

educational use

■ Contact

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- Phone: +32 9 33 14 925
- Mail: ingrid.moerman@intec.ugent.be

■ Website

- www.crew-project.eu
- <https://github.com/WirelessTestbedsAcademy>

CREW is still in OPEN ACCESS mode.

Experimenters are welcome and we will be happy to support you!