IP CREW

Cognitive Radio Experimentation World

CREW Training Days - January 14-15, 2014 - Ghent

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).

Agenda – Day 1

9:00 Welcome & introduction

9:15 Presentation: CREW at a glance
- Ingrid Moerman, iMinds, Belgium

9:45 Basic hands-on courses / demos - Part I ***(sequential courses/demos)***
* **Course 1**: Use of iMinds test facilities w-iLab.t, including IMEC spectrum sensing engine and TCS WinnF transceiver API (heterogeneous ISM)
- Pieter Becue, Wei Liu, Michael Mehari, ... iMinds & imec, Belgium
* **Course 2**: Use of TCD test facilities, including Iris reconfigurable software radio platform
- Luiz Da Silva or Paul Sutton, Trinity College Dublin (TCD), Ireland

12:30 *Lunch*

13:30 Basic hands-on courses / demos - Part II ***(sequential courses/demos)***
* **Course 3**: Use of TUB test facilities TWIST (wireless sensor network)
- Mikolaj Chwalisz, Technische Universitat Berlin (TUB), Germany
* **Course 4**: Use of TUD test facilities (LTE advanced)
- Rohit Datta or Martin Danneberg, Technische Universitat Dresden (TUD), Germany
* **Course 5**: Use of JSI test facilities (ISM/TVWS outdoor)
- Matevz Vucnik, Jožef Stefan Institute (JSI), Slovenia

18:00 End of Day 1

19:00 *Dinner (on your own expense but organised by iMinds if interested)*

Agenda – Day 2

9:00 In depth hands-on courses - Part I ***(parallel courses)***

* **Course A**: Use of iMinds test facilities w-iLab.t, including IMEC spectrum sensing engine (heterogeneous ISM)
- Pieter Becue, Wei Liu, Michael Mehari, ... iMinds & imec, Belgium
* **Course B**: Use of TCD test facilities, including Iris reconfigurable software radio platform
- Luiz Da Silva or Paul Sutton, Trinity College Dublin (TCD), Ireland

12:30 *Lunch*

13:30 In depth hands-on courses - Part II ***(parallel courses)***

* **Course C**: Use of TUB test facilities TWIST (wireless sensor network)
- Mikolaj Chwalisz, Technische Universitat Berlin (TUB), Germany
* **Course D**: Use of JSI test facilities (ISM/TVWS outdoor)
- Matevz Vucnik, Jožef Stefan Institute (JSI), Slovenia

17:30 End of Day 2

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Project overview

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Outline

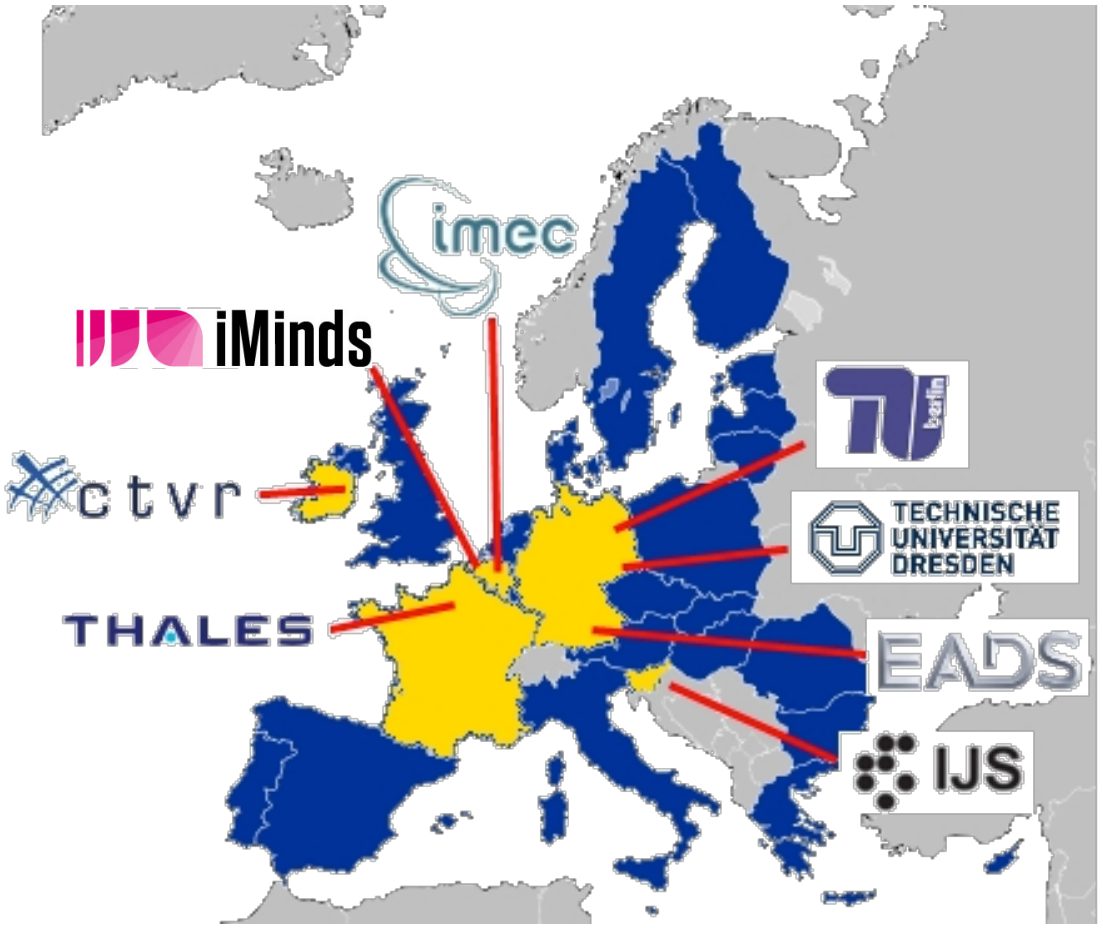
- Partners
- Motivation
- Main objectives
- CREW platform
- CREW offer
- Roadmap

IP CREW - Partners

- **Cognitive Radio Experimentation World**
  - FP7 call 5 (FIRE - Future Internet Research and Experimentation Initiative)
  - Project started October 2010
  - 8 core partners
  - 3+6 open call partners
    - UDUR (UK)
    - TUIL (DE)
    - TECNALIA (ES)

    OC1
    - IT (PT)
    - CMSF (PT)
    - CNIT (IT)
    - WINGS (GR)
    - UTH (GR)
    - NICTA (AU)

    OC2



IP CREW - Partners

- **Open Call 3 experimenters**
  - Paris Descartes University (France)
  - Paris-Sud University (France)
  - Technical University of Cluj-Napoca (Romania)
  - AED Engineering GmbH (Germany)
  - TASS (Belgium)
  - Ss. Cyril and Methodius University in Skopje (Macedonia)
  - Katholieke Universiteit Leuven (Belgium)
  - Televic Healthcare (Belgium)

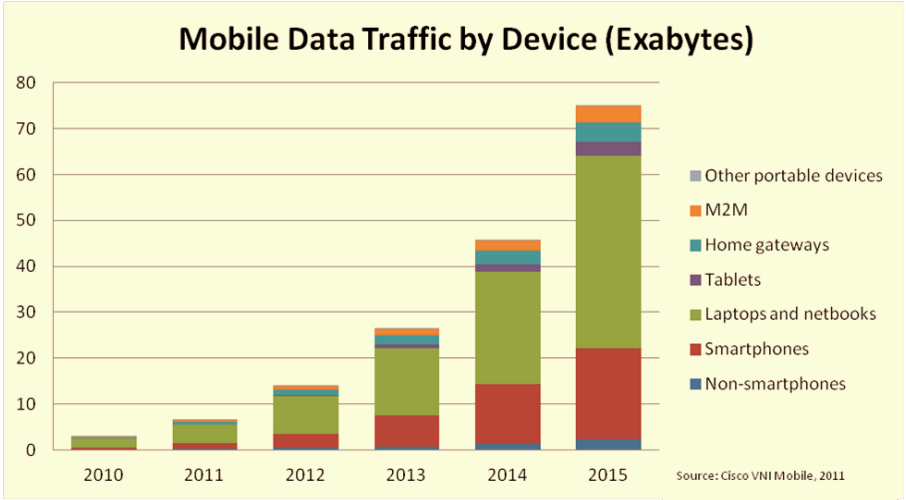
- **Practicalities**
  - Signature of Memorandum of Understanding
  - OC3 mailing list

CREW – Why?

The Internet plays a crucial role in interconnecting technologies and services…

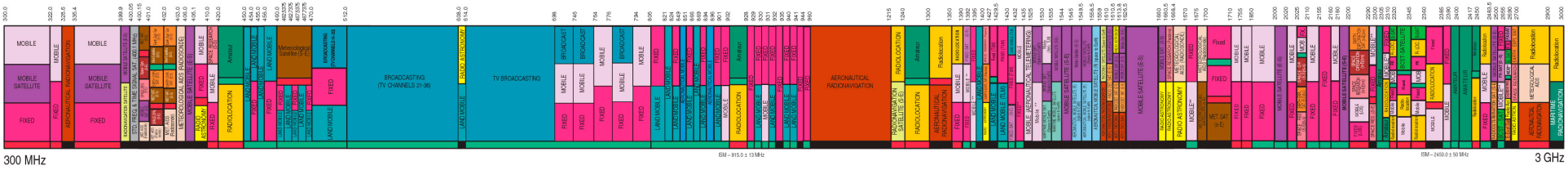
… resulting in increasing complexity

- more users, more types of users
- more devices, more type of devices (Internet of Things)
- **increasing wireless traffic demand!**



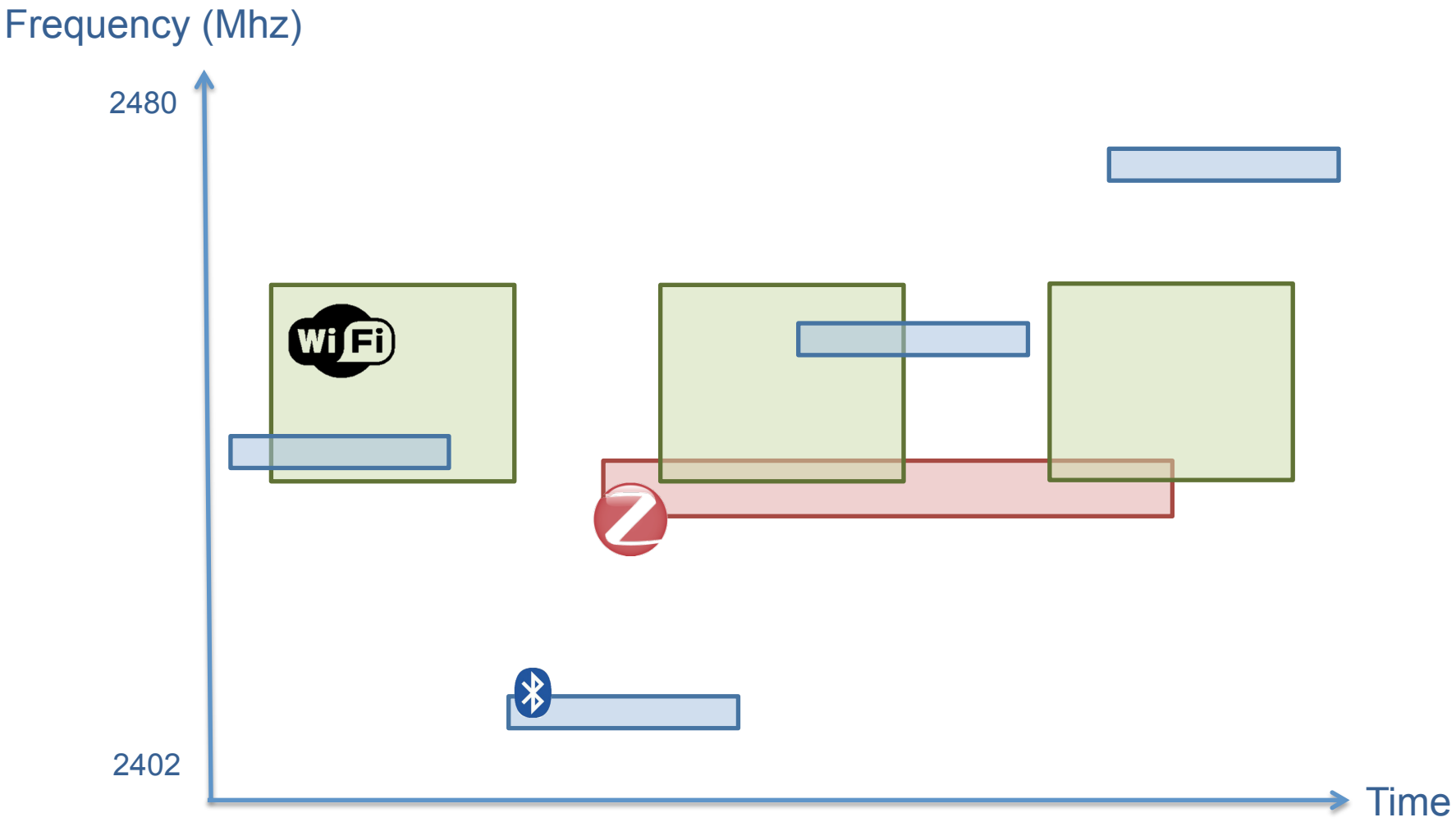
BUT… radio spectrum is limited!

- big differences depending on the frequency band
  - white spaces in licensed bands versus overcrowded unlicensed bands



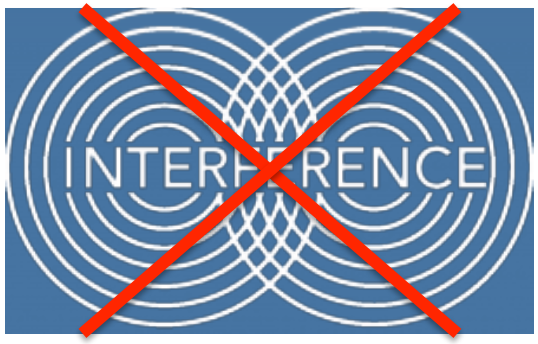
Overcrowded unlicensed bands

- **Problem**
  - Time & frequency collisions in 2.4 GHz ISM band



Coexistence in unlicensed bands

- **Research questions**
  - How to avoid collisions?
    - passive interference avoidance
    - true cooperation between technologies
  - How to guarantee QoS in wireless networks?
  - How to reduce human exposure?
  - How to limit energy consumption in wireless devices?

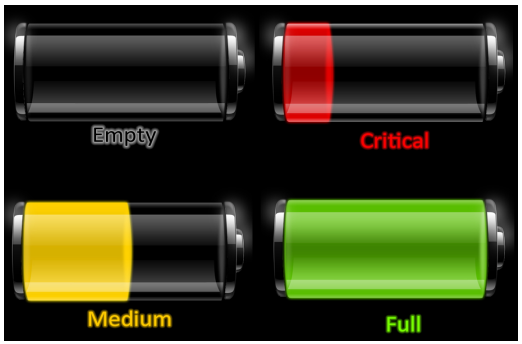


➔ Need for low-energy, low-cost spectrum sensing techniques

➔ Need for more dynamic interference avoidance techniques

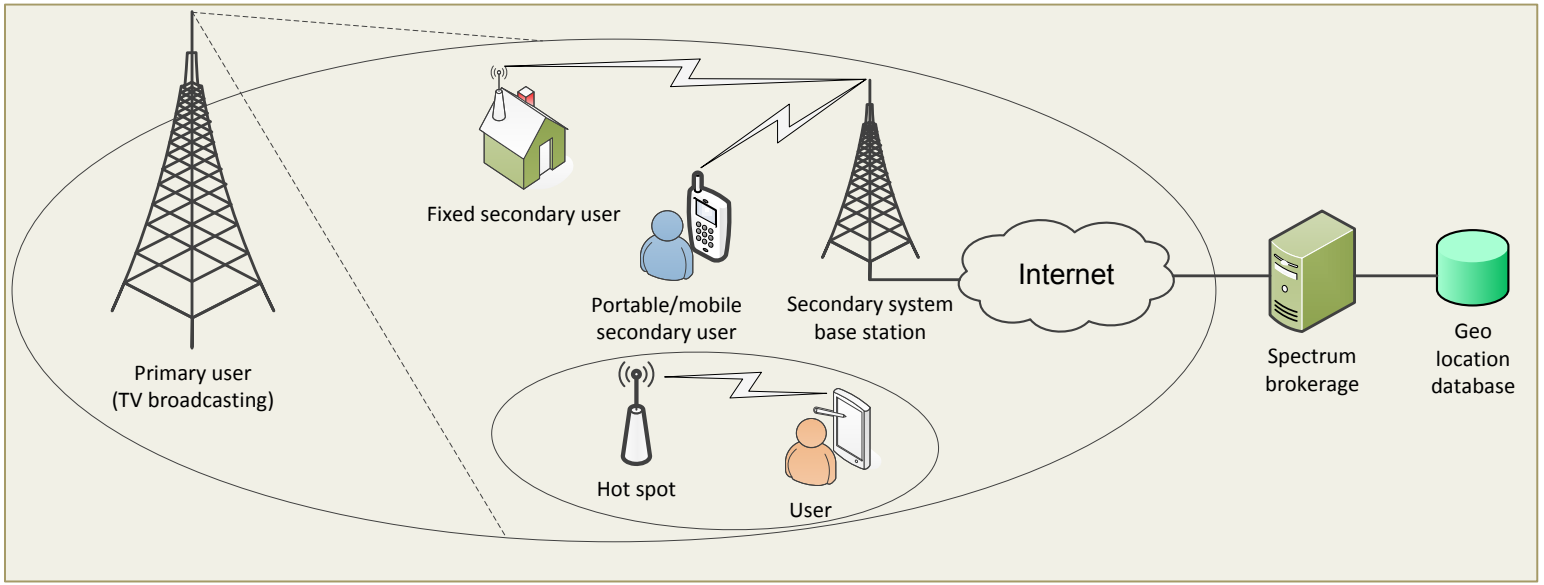
➔ Need for energy efficient, cooperative networking

- e.g. cooperative MAC, cooperating routing



White spaces in licensed bands

- **From exclusive access by primary (licensed) user (PU) only…**
  - ***Problem***: underutilized spectrum in temporal and spatial domain
    → white spaces or spectrum holes
- **… to dynamic spectrum access by secondary users (SU)**
  - increased spectrum utilization by using white spaces

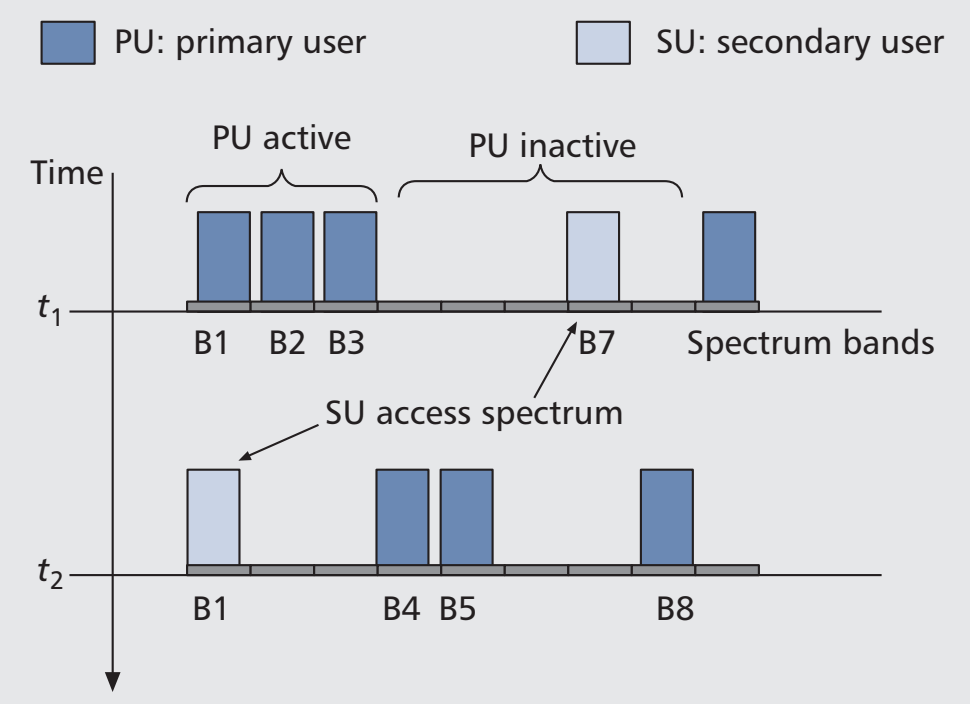


- **Research questions**
  - How SUs can use white spaces without degrading PU performance?
  - How can SU sense PU activity?

White spaces in licensed bands

Dynamic Spectrum Access models (1)

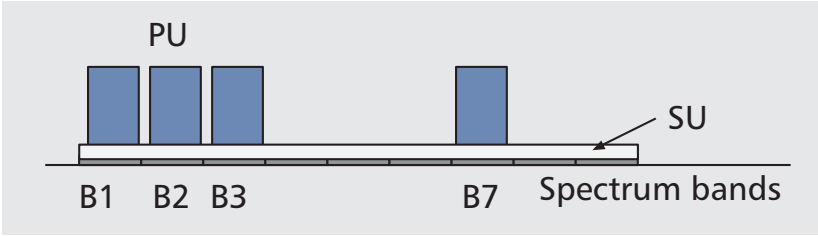
- **Interweave DSA model or opportunistic spectrum access**
  - utilize white spaces in the temporal, spatial, and/or frequency domain



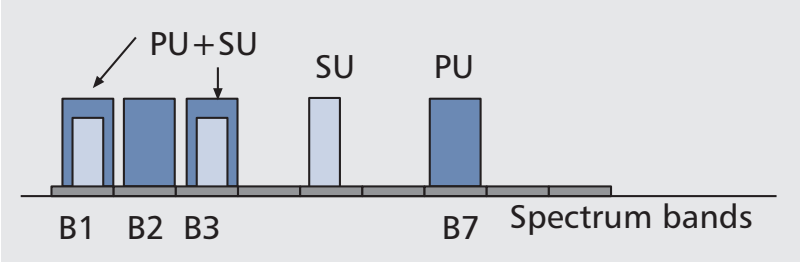
- two approaches
  - centralized spectrum sharing
    - central (remote) coordinator: spectrum broker
    - geo-location database
    - location of Secondary User (SU)
  - distributed spectrum sharing
    - local spectrum sensing
    - cooperative spectrum sensing

White spaces in licensed bands

- **Dynamic Spectrum Access models (2)**
  - **Underlay DSA model**
    - SU can transmit on a spectrum band no matter the PU is active or not
    - low power transmission to limit interference



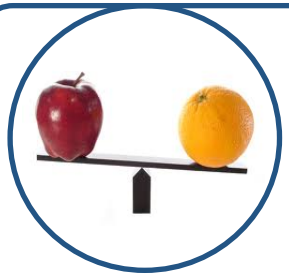
  - **Overlay DSA model**
    - SU can transmit on a spectrum band with a large power even when the PU is active
    - maintaining PU performance



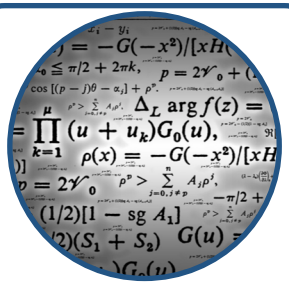
CREW – Why?

From novel idea to commercial use …

… experimentally-supported research is crucial for validation of new CR/CN concepts



compare the performance of multiple solutions



theory vs. reality: impact of real-life deployment

showcase for industry, regulators and government

reduce the time to market

understand how people experience and use technology

CREW – Why?

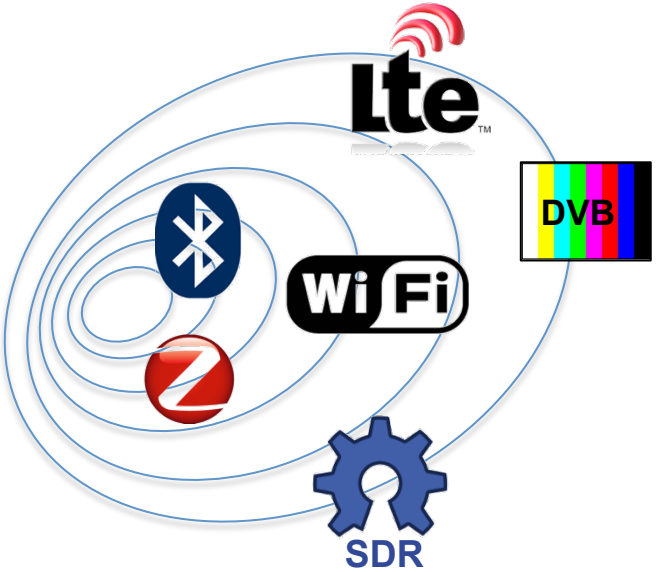
- **Wireless developer's questions**
  - **How to evaluate cognitive radio / cognitive networking solutions?**
    - … in a configurable environment
    - … in a repeatable way
    - … allowing fair comparison of results
  - **Should/can I build my own heterogeneous testing environment?**

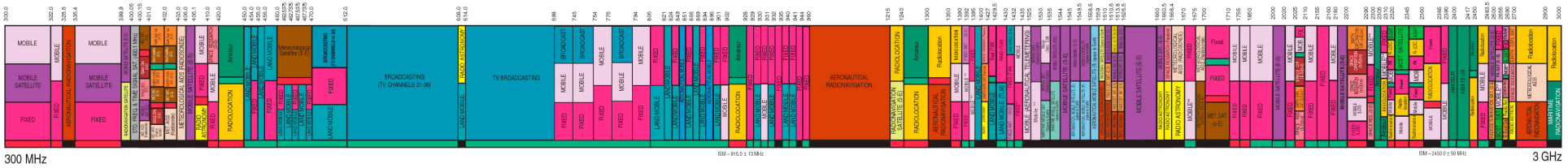





IP CREW: Objectives

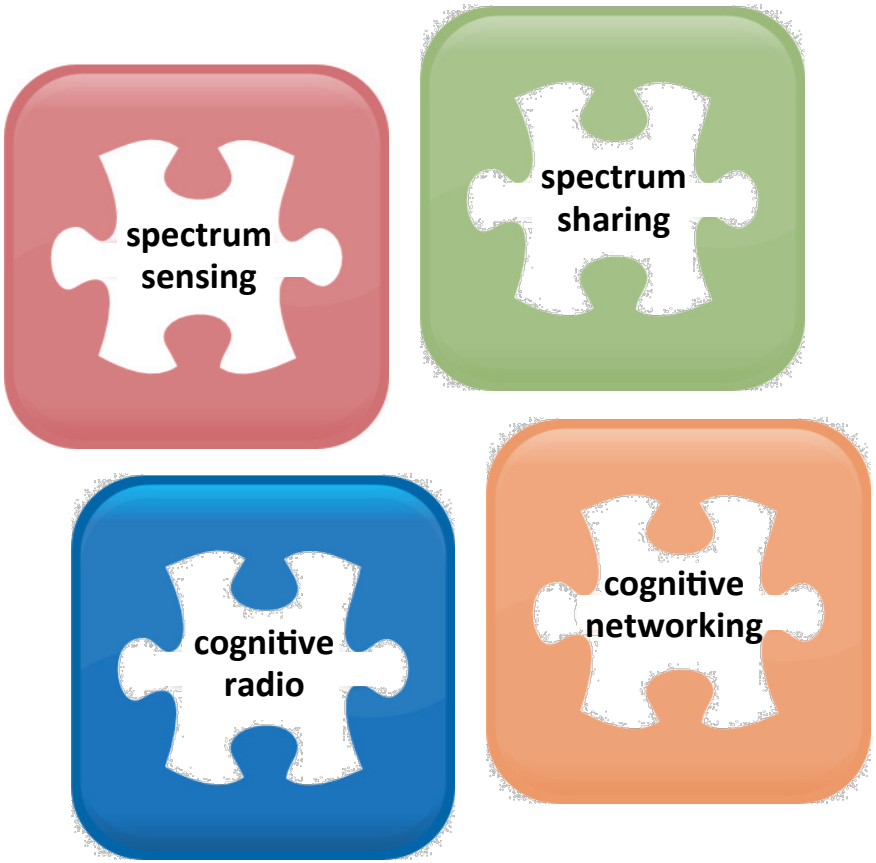
- **establish an open federated test platform, facilitating experimentally-driven research on**
  - advanced spectrum sensing
  - cognitive radio (CR)
  - cognitive networking (CN)
  - spectrum sharing
    in licensed and unlicensed bands

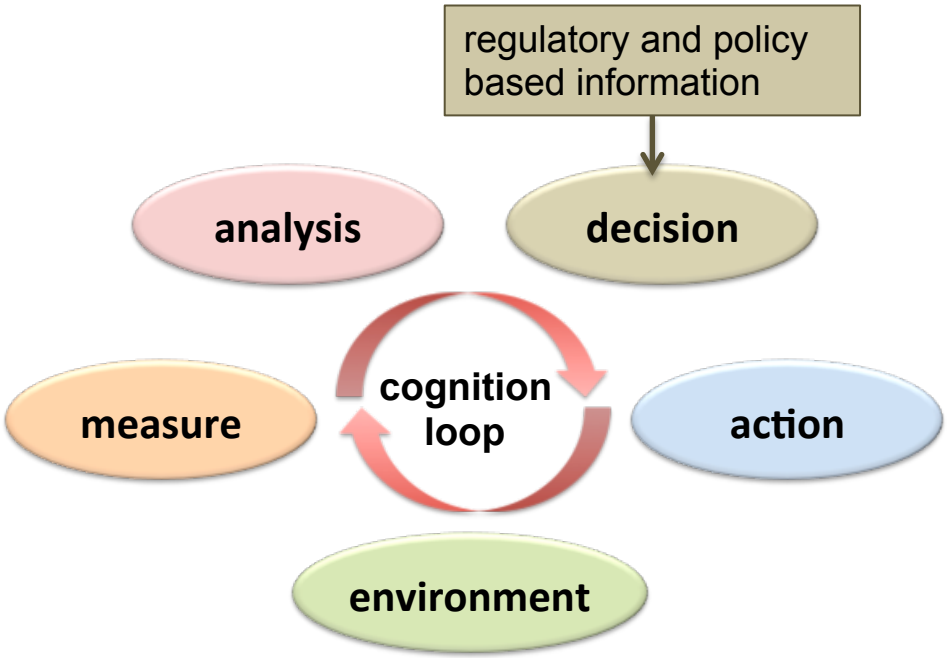




IP CREW: Objectives

- **Supporting research on CR and CN solutions**
  - use the available (spectrum) resources as efficiently as possible, by adapting the radios (transmitters and receivers) and networks to the wireless environment and the user needs

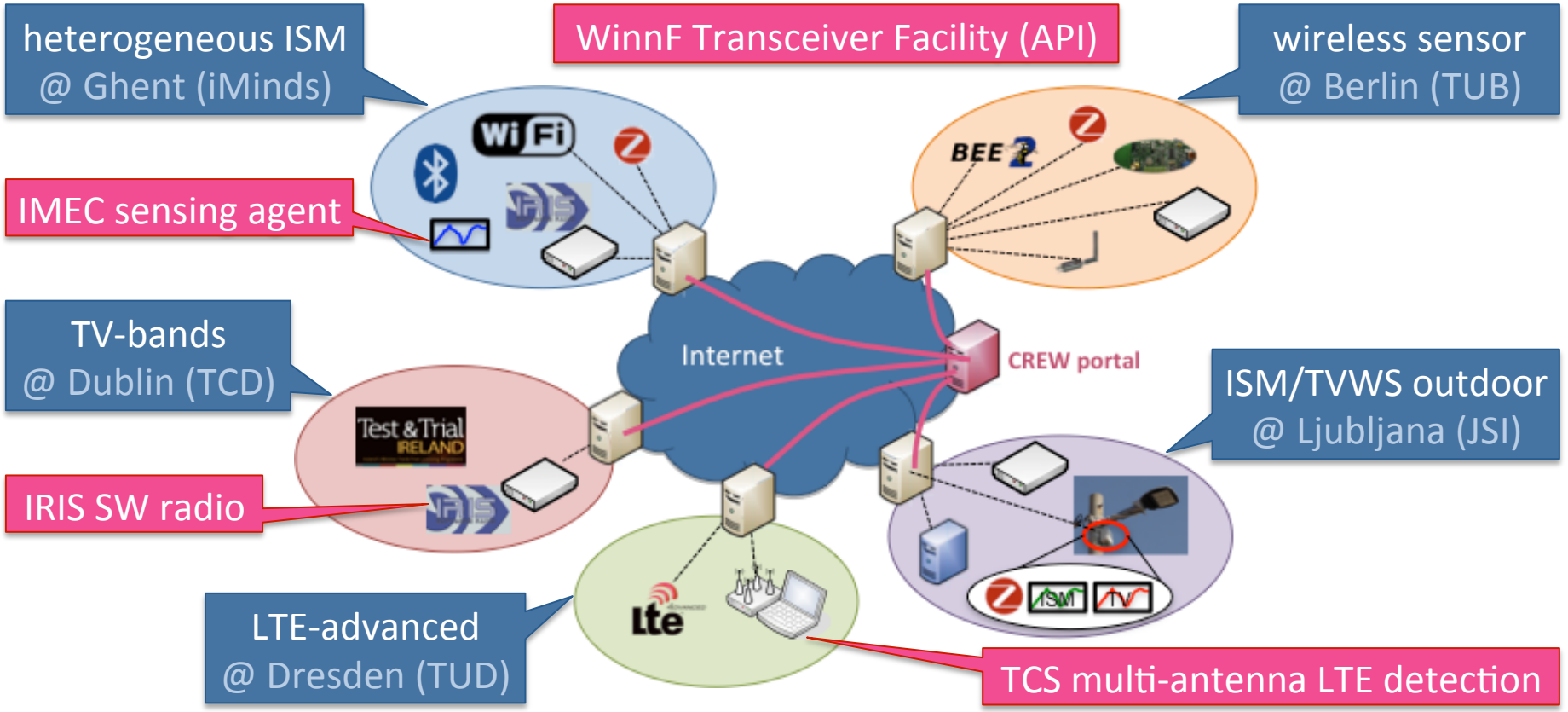




IP CREW: Objectives

- **CREW is NOT …**
  - doing research on spectrum sensing, cognitive radio & cognitive networking concepts
  - designing new algorithms
- **CREW is …**
  - bringing together test facilities for supporting research on spectrum sensing, cognitive radio & cognitive networking
  - augment existing facilities with novel cognitive components
  - bringing together expertise on experimentation
  - facilitating access to heterogeneous test facilities
  - researching & offering better methodologies for experimentation (repeatability, reproducibility, comparability)
  - validating advanced cognitive solutions (new concepts & algorithms) using CREW facilities and CREW methodologies

CREW federated platform



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	BEE2 FPGA platform	ISM bands sensing
LTE-advanced	USRP software radio	TCS Multi-antenna LTE detection
EyesIFX nodes	VESNA platform on light pole	WiSpy Spectrum analyzer
CR database		Interconnection of portals
		Interconn. between testbed elements

CREW Federated platform: key aspects

- **common portal**
  - comprehensive **description** of the individual testbeds
  - **guidelines** on how to access and use the federated testbed
- **novel cognitive components**
  - **relocation** of components
  - **linking together** software and hardware **entities** from the different partners
  - **standardized API** for SDR architectures (developed within WINNF)
- **creation of open data sets**
  - a **common data structure** based on IEEE 1900.6 standard enabling
    - sharing of experiment descriptions, traces, data processing scripts…
    - spectrum sensing using heterogeneous sensing hardware
- **benchmarking framework**
  - enabling experiments under controlled and **reproducible test conditions**
  - allowing **fair comparison**
  - offering **automated procedures** for experiments and performance evaluation

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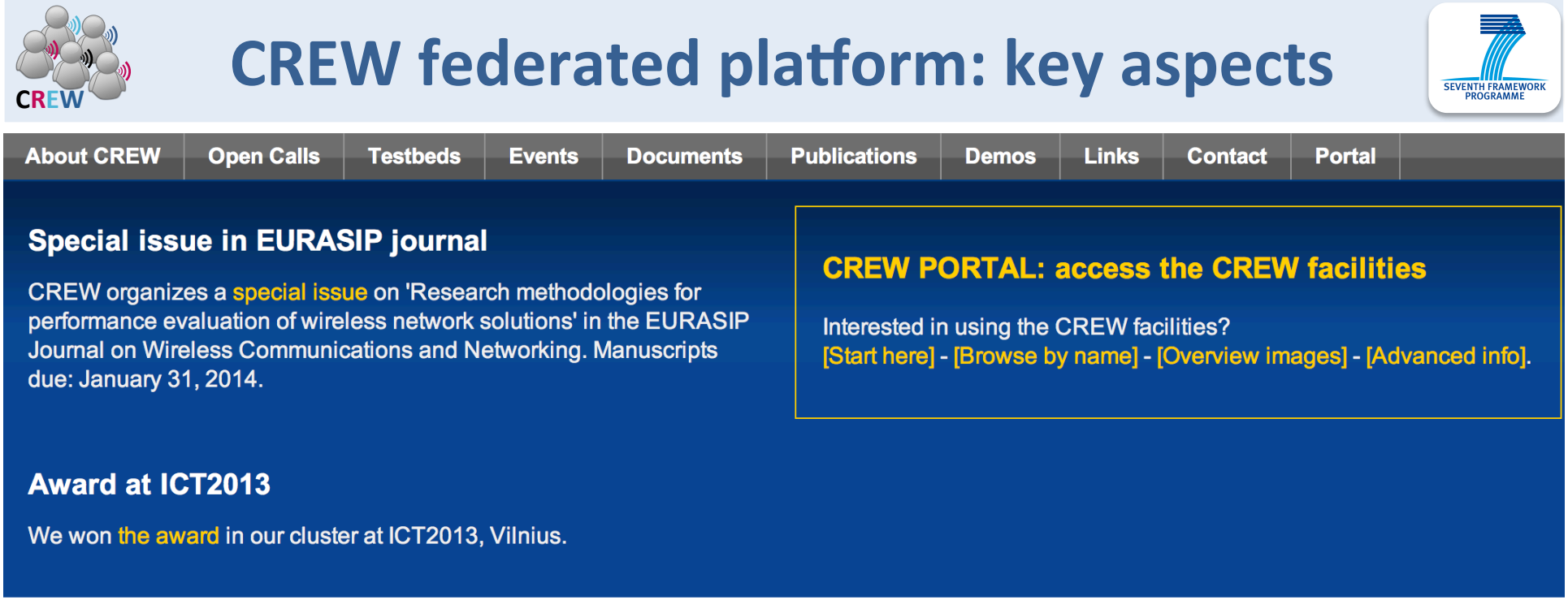
CREW federated platform: key aspects

- **common portal**
  - www.crew-project.eu

  - description of the facilities, cognitive components and tools
  - usage policies
  - requesting accounts
  - getting started: tutorials

CREW federated platform: key aspects



CREW federated platform: key aspects

- **common portal**

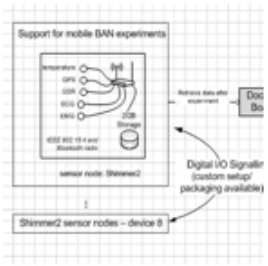
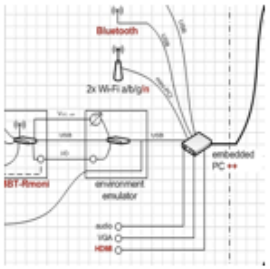
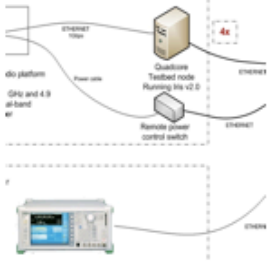
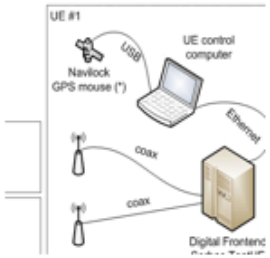
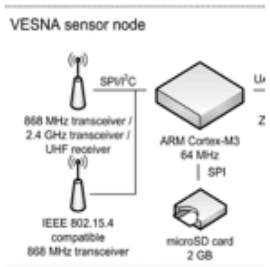
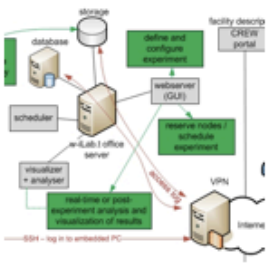
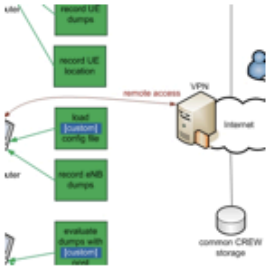
Portal: advanced documentation

- Schematic overview
- IRIS documentation
- LTE advanced documentation
- TWIST documentation
- w-iLab.t documentation
- imec sensing engine
- LOG-a-TEC documentation
- Common data format
- Transceiver Facility Specification
- CREW benchmarking tools
- Experimentation methodology

Home » Portal: advanced documentation

Schematic overview

Please click the thumbnail extracts below to get a full screen view of the different infrastructures. After clicking the thumbnails, click to zoom in. The images may also be downloaded on the bottom of this page.

TWIST - Berlin	w-iLab.t - Gent	Iris - Dublin	LTE-Advanced - Dresden	Log-a-tec - Ljubljana
 Hardware overview	 Hardware overview	 Hardware overview	 Hardware overview	 Hardware overview
 Usage overview	 Usage overview	 Usage overview	 Usage overview	 Usage overview
Access documentation	Access documentation	Access documentation	Access documentation	Access documentation

CREW Federated platform: key aspects

- **common portal**
  - comprehensive **description** of the individual testbeds
  - **guidelines** on how to access and use the federated testbed
- **novel cognitive components**
  - **relocation** of components
  - **linking together** software and hardware **entities** from the different partners
  - **standardized API** for SDR architectures (developed within WINNF)
- **creation of open data sets**
  - a **common data structure** based on IEEE 1900.6 standard enabling
    - sharing of experiment descriptions, traces, data processing scripts…
    - spectrum sensing using heterogeneous sensing hardware
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CREW Federated platform: key aspects

- **Novel cognitive components**
  - **relocation** of components
  - **linking together** software and hardware **entities** from different partners

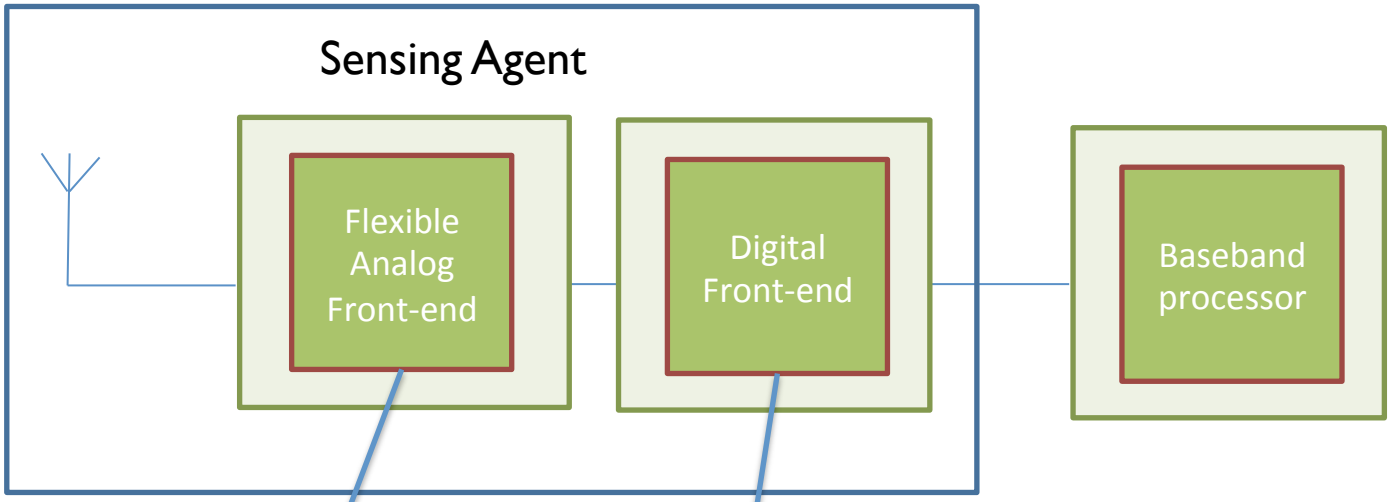
iMinds

imec

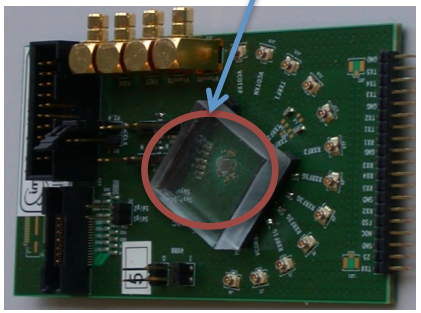
ctvr

CREW Federated platform: key aspects

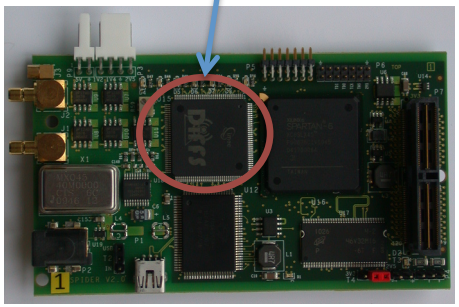
- **Novel cognitive components: imec Sensing Agent**
  - Versatile spectrum sensing engine building on reconfigurable radio elements
  - Low power/area/cost targeted to enable use in mobile devices



imec's Scaldio2b

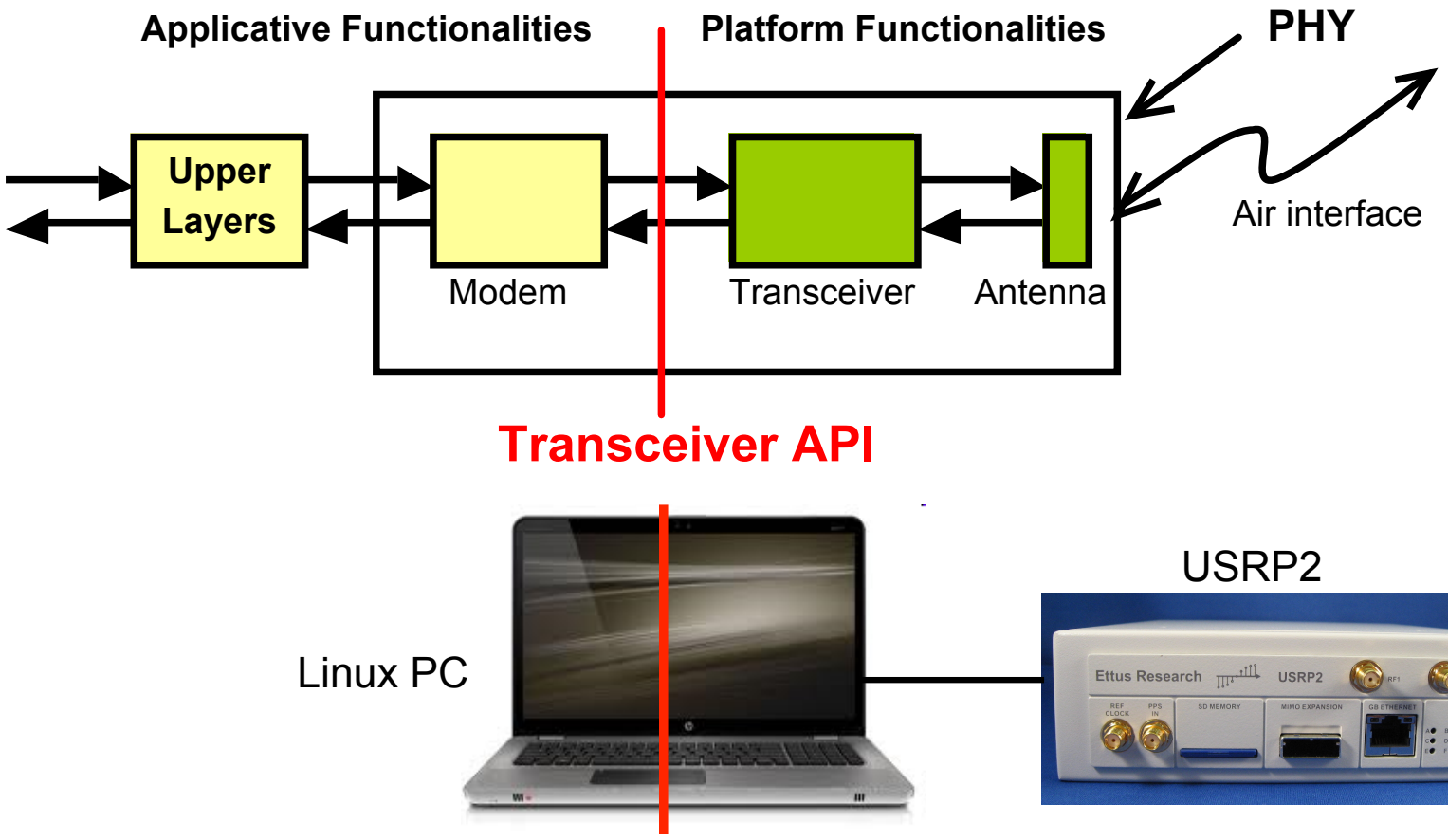


imec's DIFFS



CREW Federated platform: key aspects

- **Novel cognitive components: transceiver API**
  - **standardized API** for SDR architectures (developed within WINNF)
  - functional specification for command and control of RF hardware platforms



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CREW Federated platform: key aspects

- **Creation of open data sets**
  - **CREW repository** (www.crew-project.eu/repository)

GitHub

html	sample plots
.gitignore	bump version number
Contents.m	bump version number
LICENSE	Create LICENSE
README.md	change title
creatCDF_USRP.m	crew common data format
createCDF_Airmagnet.m	crew common data format
createCDF_imec.m	crew common data format
crewcdf_imagesc.m	add documentation to the plotting functions
crewcdf_imec.m	crew common data format
crewcdf_integratePSD.m	crew common data format
crewcdf_load.m	detect fsv files in the load function
crewcdf_loaddir.m	crew common data format
crewcdf_plotpers.m	rename crewcdf_heatmap to crewcdf_plotpers

CREW Federated platform: key aspects

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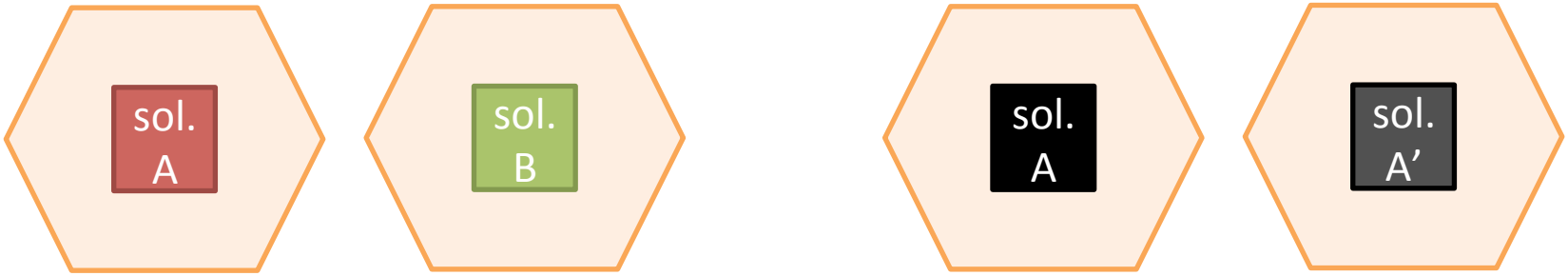
CREW Federated platform: key aspects

- **Benchmarking**
  - is the act of measuring and evaluating
    - cognitive hardware components
    - cognitive software components
  - under reference conditions
  - relative to a reference evaluation

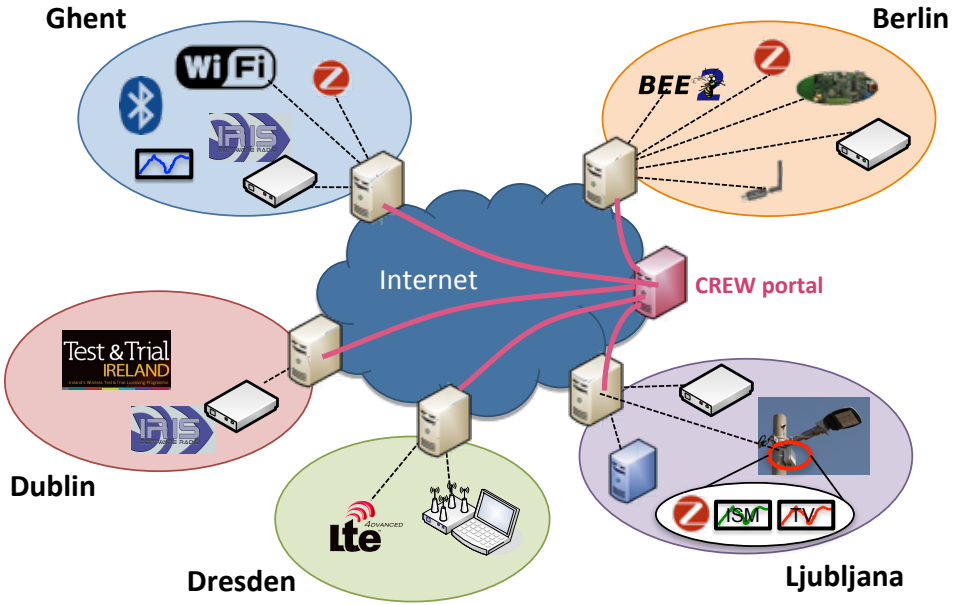
  - **Primary goal**
    - Enable fair comparison
      → objective performance indication of CR/CN concepts



Compare different solutions **Compare subsequent developments**

The CREW offer

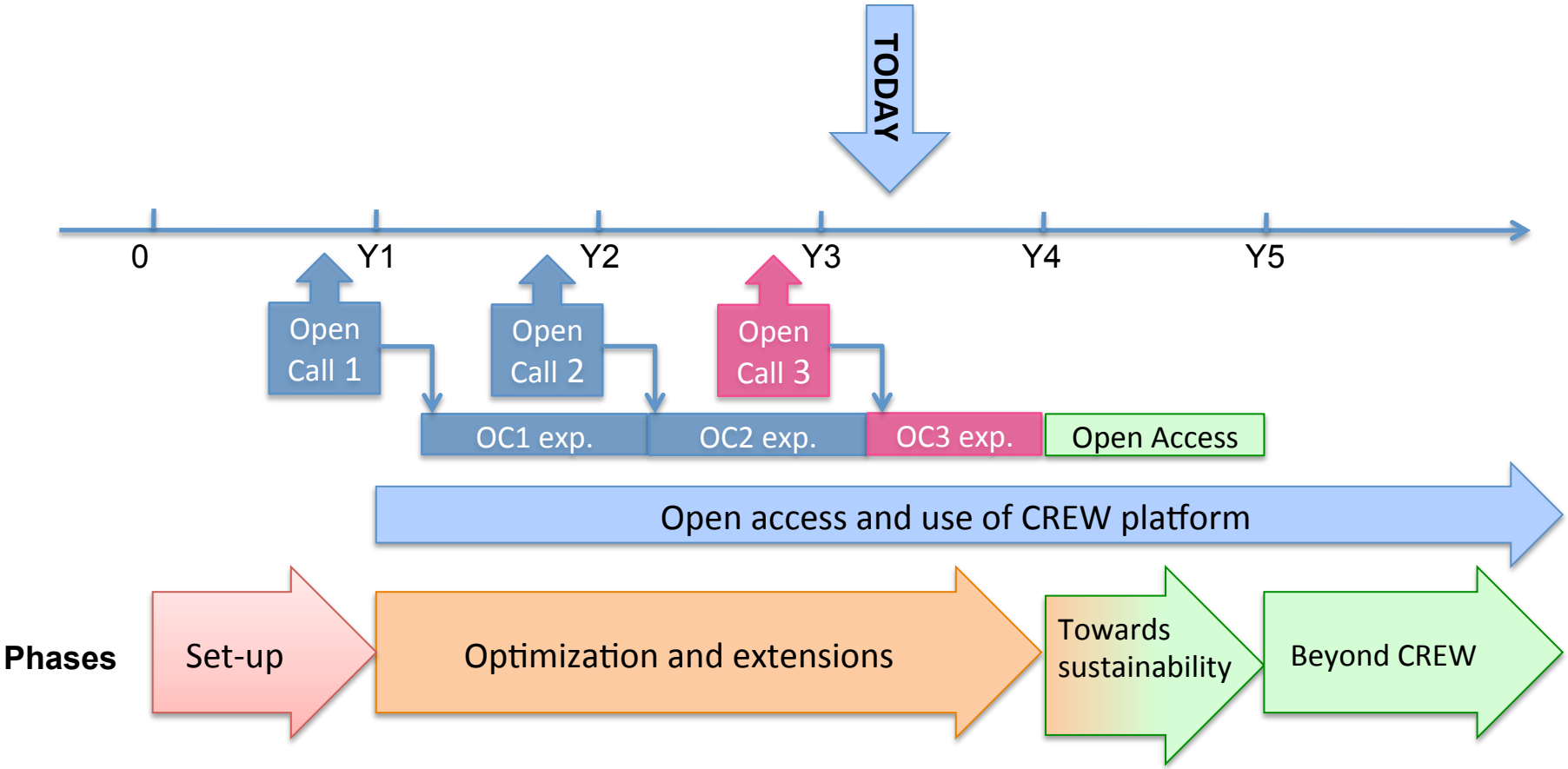
- **Open access to 5 different testbed islands and advanced cognitive components**
  - different wireless technologies
  - different spectrum bands
  - mature testbeds
  - methodologies and tools for experimentation
  - reproducible test conditions
  - expertise from PHY layer to application layer



- **Portal with detailed information and guidelines on access and use of the facilities (www.crew-project.eu)**

- **Technical support & assistance to experiments**
  - Training & best practices for experimentation
  - open call 3 / open access for free and guaranteed support to experiments

CREW Roadmap



Testimonies from CREW Open call partners

CREW provided a great opportunity to test and validate advanced cognitive radio technical developments, which was extremely difficult without CREW.

Thanks to CREW, we could have access to state-of-the-art spectrum sensing equipment.

CREW has allowed us to learn great lessons about testbed usage!

The framework for controlling wireless test infrastructure is very powerful. While such framework is originally designed for describing and running experiments, it can be also readily used for radio and network control, as part of the wireless cognitive solution under test..

The WINNF transceiver API is an extremely efficient way of controlling USRP2 devices, providing a significantly better performance comparing to previous drivers we have employed

IRIS SDR platform is extremely easy to use and is well documented. The first integration of algorithms was done in a single day! IRIS is quite stable and there haven't been detected neither bugs, nor instabilities typical of other frameworks.

Q & A

Create Connect Grow

European Commission

EU2013.LT

Laureate of ICT2013 Exhibition

This is to certify that on 8th November 2013

Cognative Radio Experimentation world

Was selected as laureate of the competition for best exhibit in the conference ICT 2013 in Vilnius, Lithuania.

Neelie Kroes

Vice-President of the European Commission

Responsible for the Digital Agenda for Europe

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