Dynamic spectrum management in relation with cognitive radio technology

ITU-D Regional Development Forum for the Arab Region:
"Access to spectrum, including broadcasting services – trends and technologies"

Tunis (Tunisia), 1 - 3 June 2009

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Outline

URC Project

URC Simulator:
towards a spectrum management tool

Disseminated Urban Sensing:
towards a “regulation oriented” architecture

Technical challenges & perspectives

International context for radio frequencies

World summit on the information society:

« … ensure rational, efficient and economic use of, and equitable access to, the radio-frequency spectrum by all countries, based on relevant international agreements.»

Liberalization of the telecom market in Europe:

« We urgently need to look at how we can **use the spectrum more efficiently** in the EU. »
Several initiatives: **WAPECS / CUS / FLEX bands**.

2012 Digital Plan in France:

BWA in Digital Dividend / White spaces / Mobile TV / Digital radio…

US Initiative, a spectrum policy for the 21st century :

Develop communication technologies and services. Satisfy homeland security, public safety, scientific research, federal transportation infrastructure and law enforcement.

International Telecommunications Union (ITU) :

WRC-07 (IMT…) and WRC-11 (Enhanced regulatory framework / CR/SDR / UAS …)

RRC06: Digital transition for broadcasting service

Cybersecurity / PPDR / New SM Handbook and ITU-R recommendations …

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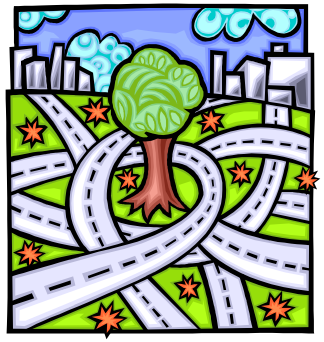
URC Project: Objectives



- Dynamic spectrum management with cognitive radio as an enabler
- Regulated context for optimization and security (monitoring, mitigation of interferences)
- Develop a Spectrum Management tool for regulation
- Urban constraints (density, daily migrations, events, landscape); Paris region is representative

URC Project: at a glance

- Funding
  System@tic program framework
- French Spectrum Agency
- Telecom, transport, broadcasting operators
- Industries, Equipment
- Technological SMEs
- Academic

Started October 2006, duration 3 years

URC Project: technical Content

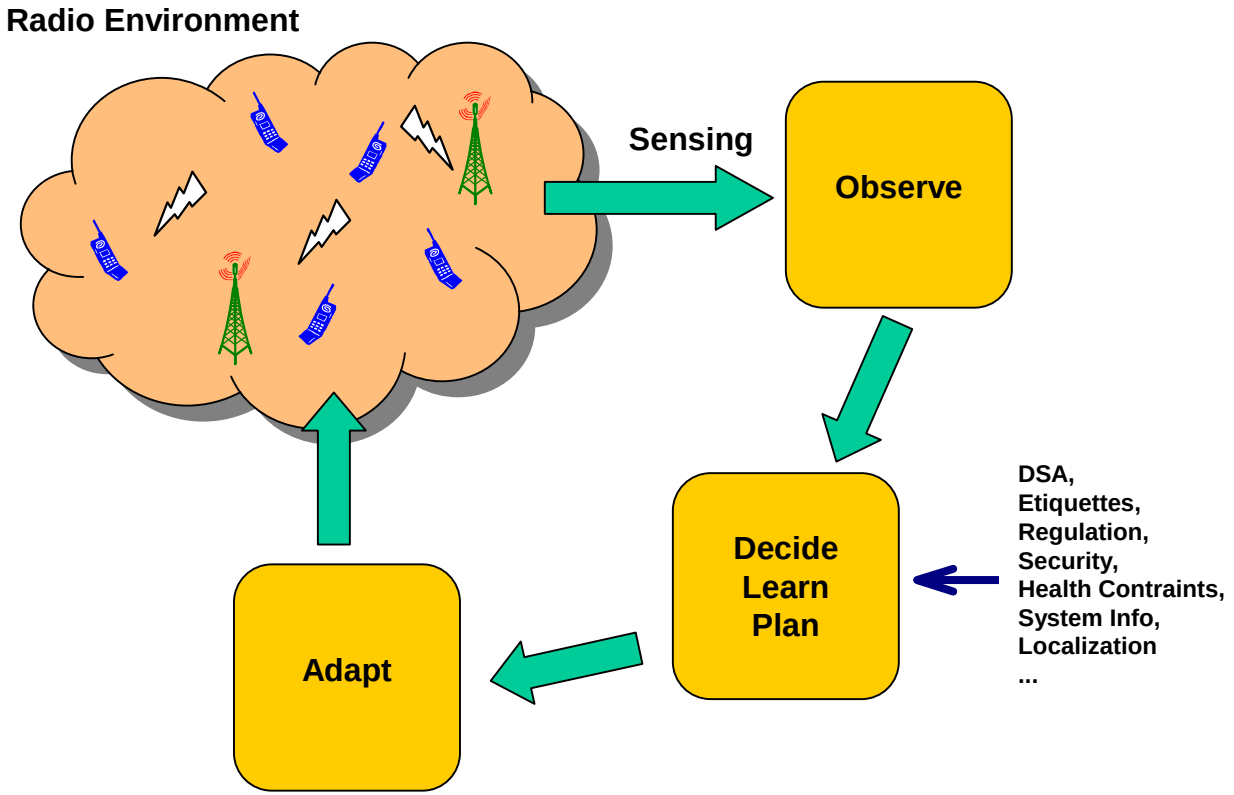
- Use of Cognitive Radio paradigm
- System level
  - Operational scenarios, evolution scenarios, DSA, xRRM, architecture, traffic modeling, …
- Technological bricks
  - Propagation modeling, new radio access schemes, cooperative schemes, metrology/sensing, …
- Simulation
  - Propagation simulation
  - High level simulator showing the benefit brought by a dynamic spectrum management based upon developed models

Cognitive radio

World Radiocommunications Conference 2007

WRC 2011 AI 1.19 : to consider regulatory measures and their relevance, in order to enable the introduction of software-defined radio and cognitive radio systems, based on the results of ITU-R studies, in accordance with Resolution 956 (WRC-07).

RESOLUTION 956 (WRC-07) : Regulatory measures and their relevance to enable the introduction of software-defined radio and cognitive radio systems



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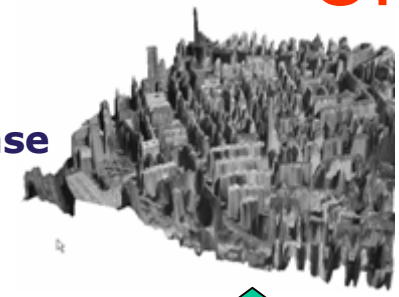
URC simulator: overview

Cartographic data base

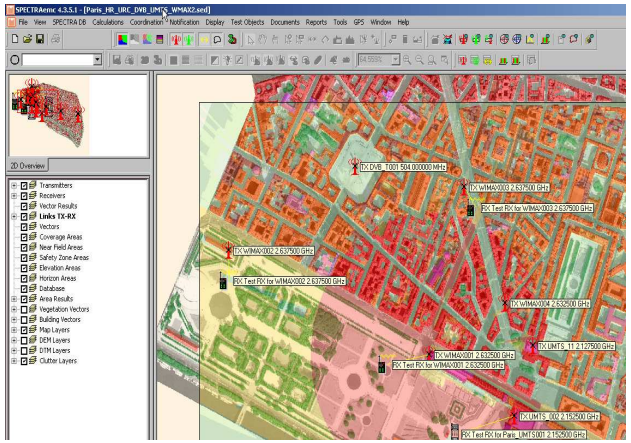


Assessment of performance enhancement

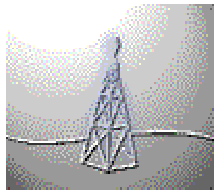
Large scale models
(space-time traffic, propagation interference, …)

Geographic area associated to the scenario

Small scale models
(mobility, terminal, radio access, …)



Objective performances
(Qos, revenues …)



Dynamic access and Cognitive Radio schemes

Performance assessment:
- ✓**Radio (spectral efficiency, power, coverage, interference)**
- ✓**Network (blocking rate, delay, number of users …)**
- ✓**Application (QoS)**

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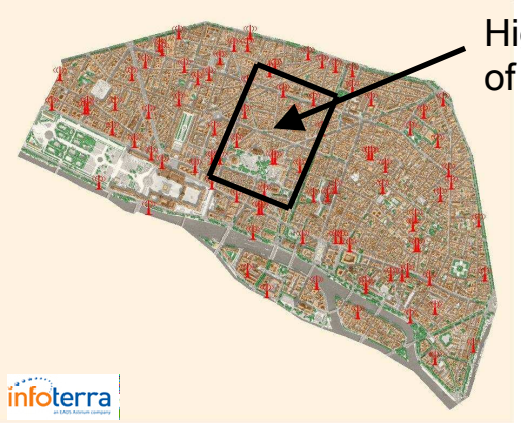
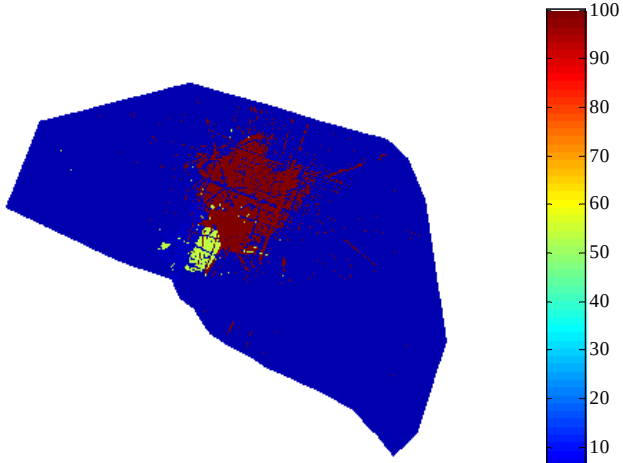
URC simulator: modeling method

- Objective:
  - Provide representative data to the large scale simulator while reducing computing time => operational tool
  - Comparison of different DSA algorithms
- Method:
  - Run small scale simulations off-line
  - Extract meaningful characteristics from the statistical data set
  - Define a simplified parametric model exploiting these characteristics
  - Integrate into the large scale simulator
  - Models also derived from measurement campaigns
    - Need of validated space-time traffic models
    - Models must be based on measurements of real traffic for existing networks

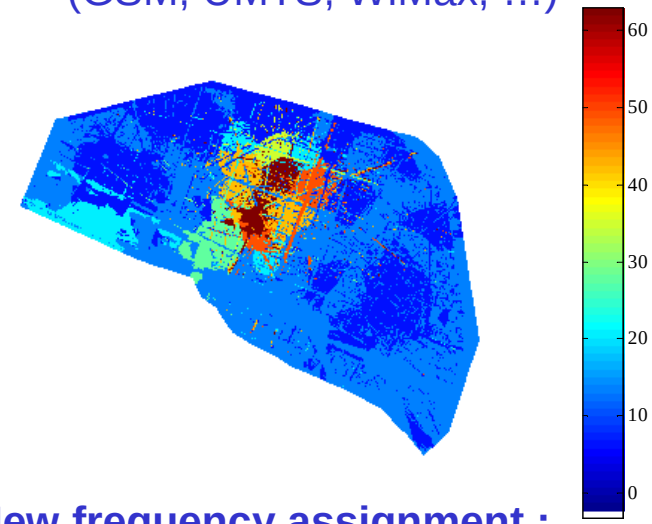
Simulation of “exceptional event” scenario



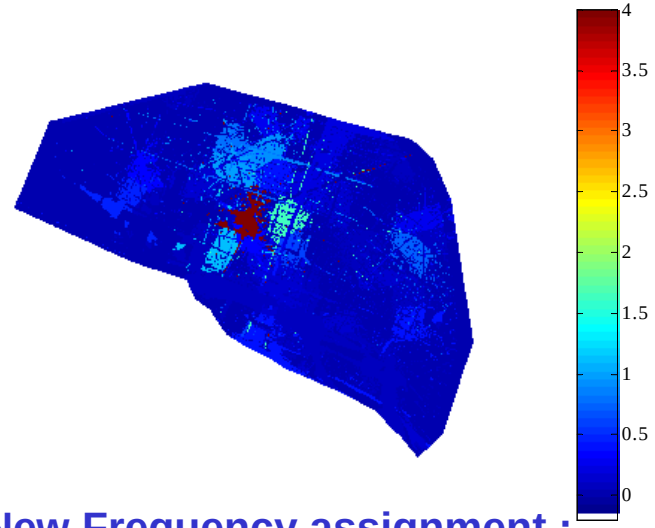
Base stations deployment
(GSM, UMTS, WiMax, …)



Blocking calls per cell



New frequency assignment :
Number of communication channels per cell



New Frequency assignment :
Blocking calls per cell

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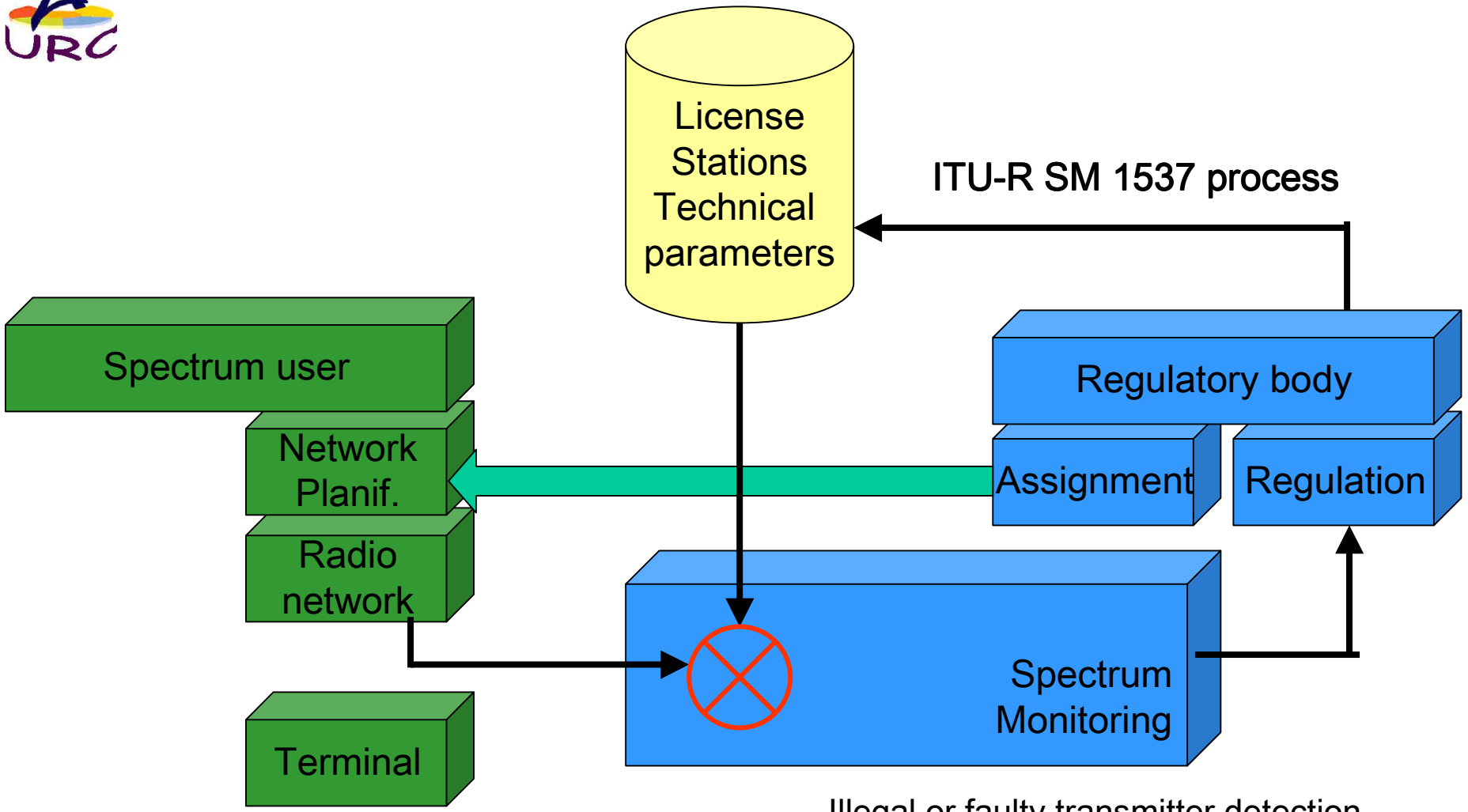
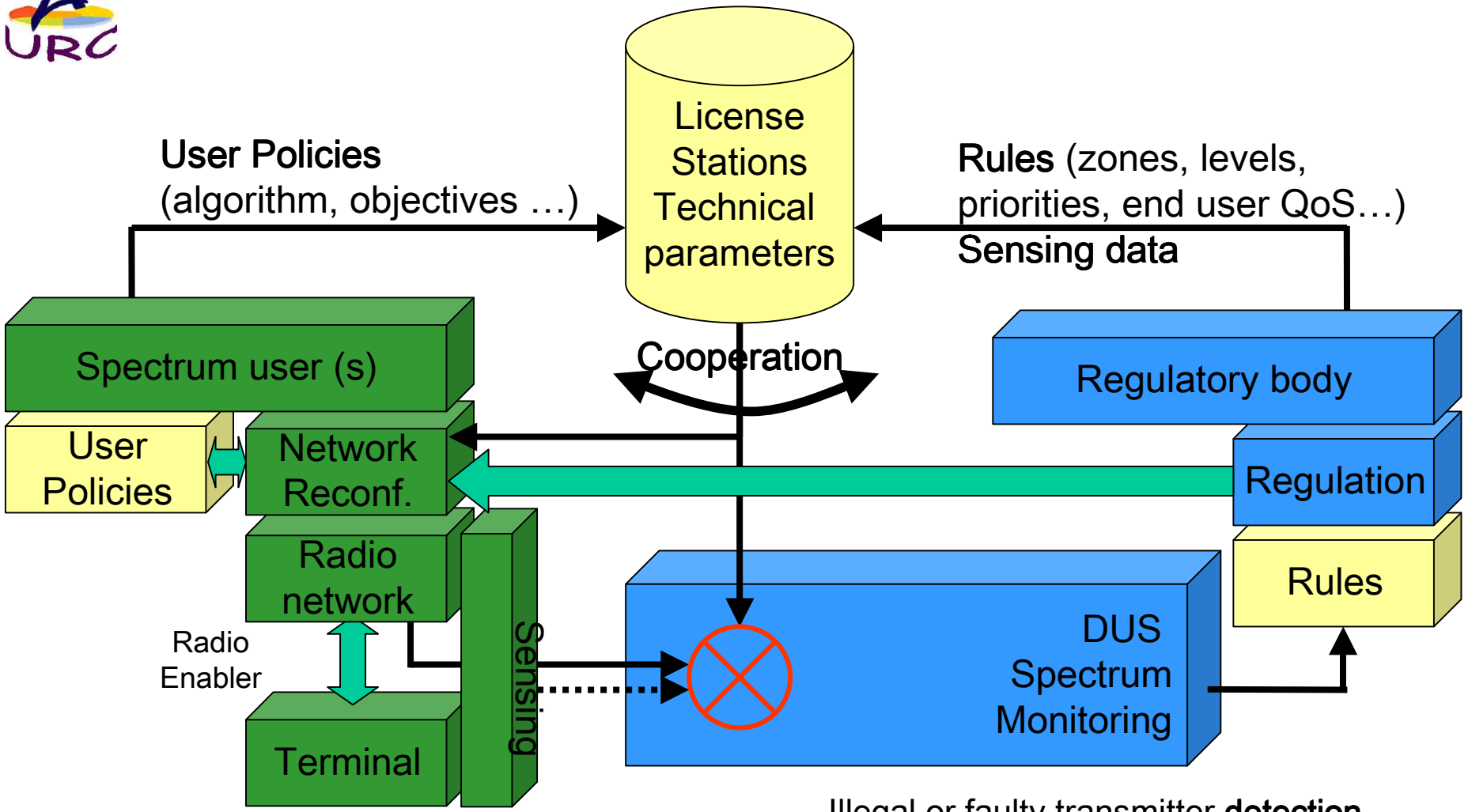
Technical challenges & perspectives

Static management



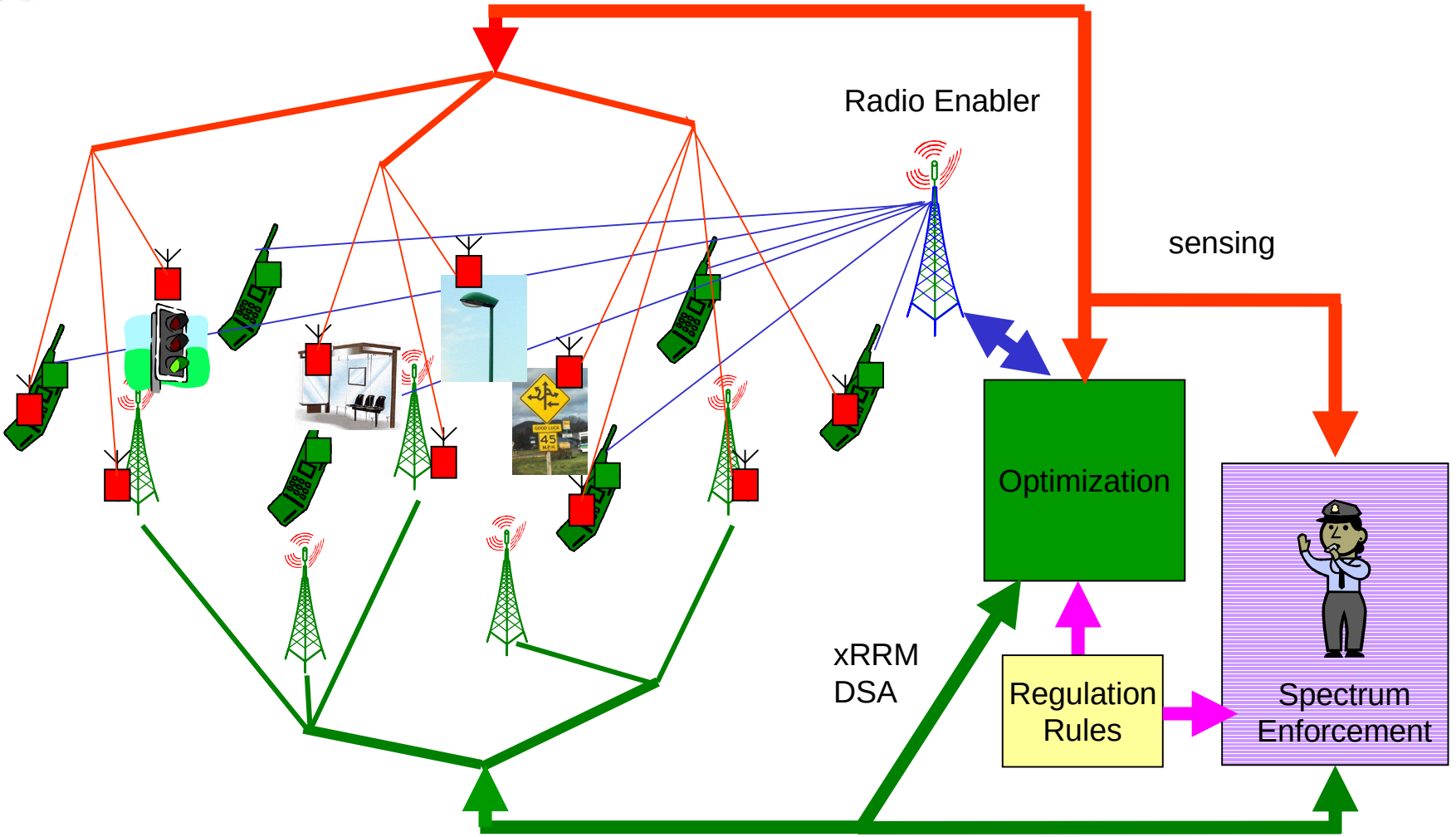
Illegal or faulty transmitter detection
Localization
Actual spectrum utilization

Dynamic management



Illegal or faulty transmitter **detection and localization**
Regulation & Rules violation
Real time spectrum utilization

Disseminated Urban Sensing



Relevant models for DUS

Management Models	Spectrum access	Regulators' role	Example
Command & Control	**Exclusive**	❑ Allocate spectrum and defines rules ❑ Monitor spectrum use (exclusive use) ❑ Enforce rules	❑ Public safety ❑ Aeronautical ❑ Broadcasting
Operator sharing	**Long term sharing**	❑ Deliver the license to the operator ❑ Exclusive use	❑ UMTS
	Dynamic sharing	❑ Allocate and monitor the band (Inside band is managed by the licensee) ❑ Dynamic exclusive use ❑ Part of band may be pre-empted in case of force majeure, regulator controls priorities	❑ Technology neutral, BEM ❑ Spectrum pooling ❑ Secondary market ❑ Crisis / big event scenarios with temporary network deployment
Secondary use of a primary licensed spectrum	**Underlay**	❑ Regulator defines rules	❑ UWB
	Overlay (opportunistic schemes)	❑ Regulator defines rules (primary/secondary) ❑ Monitor conformance of opportunistic uses with rules. ❑ Enforce rules	❑ CR/SDR ❑ White spaces ❑ Space/time optimization
Commons	**Open Spectrum**	❑ Define general rules (Tx power limitation, MAC schemes)	❑ ISM band
	Cooperative commons	❑ No license, regulator defines rules ❑ Regulator monitors the use of the band ❑ Enforce rules	❑ US Rural WISP at 3650 MHz (50 MHz unlicensed band)
	Private commons	❑ Deliver a license to a user ❑ Cooperation between other users	❑ FCC block D @ 700 MHz ❑ Femto cells

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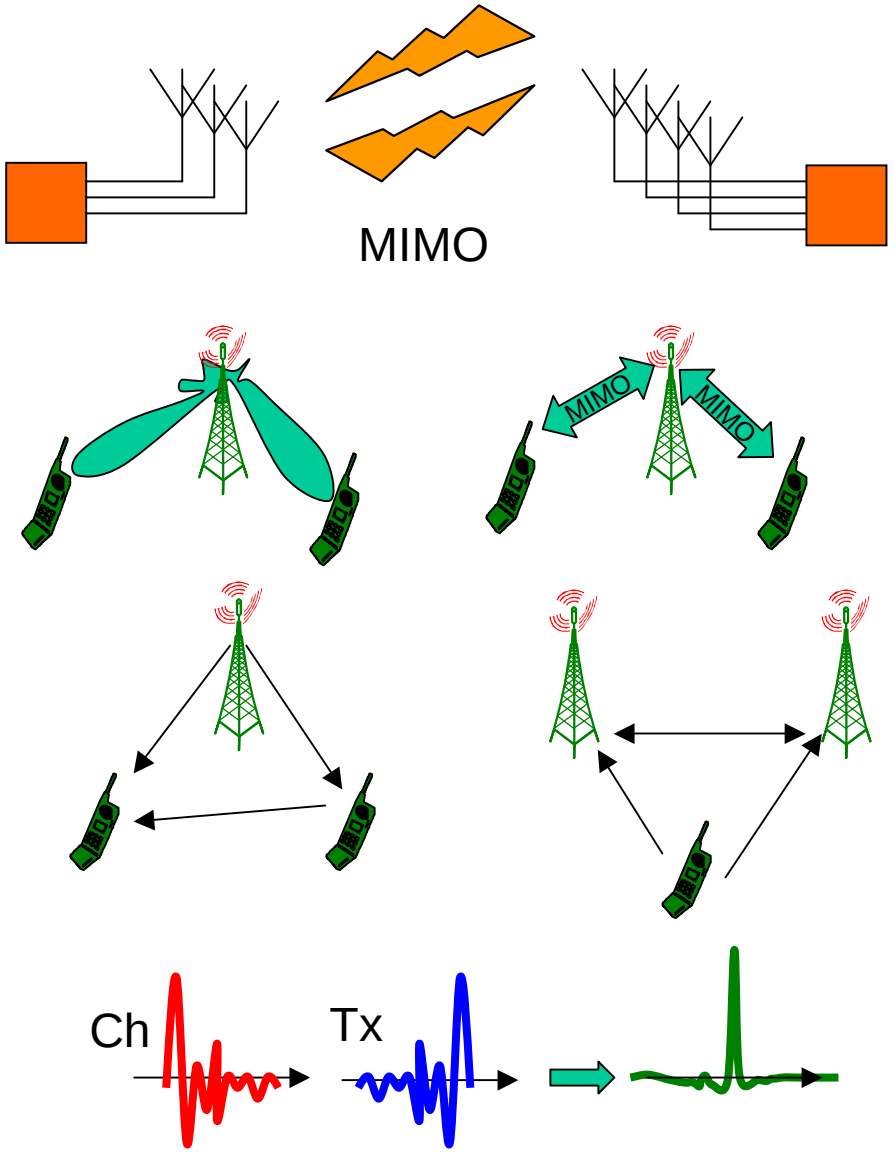
Innovative Access radio

- Joint inter/intra system resource management
- Adaptive Modulation and Coding and Hybrid ARQ
- New advanced MIMO techniques for IEEE802.11n and IEEE802.16e: Multi-user and beamforming, perfect space-time coding
- Cooperative Relaying: virtual antennas and relays, meshed and ad hoc networks
- Time Reversal



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DSA and operated networks

- How to optimize dynamically frequency and resource allocation
  - Joint RRM (JRRM), multi-RAT context, perfect roaming
  - JRRM + for agnostics bands (e.g. GSM900, UMTS900)
  - DSA: Dynamic Spectrum Allocation
    - “Meta operator” or mono operator
    - IEEE P1900.4 Architecture
    - Dynamic Spectrum Access (common pool)
    - Hybrid (dedicated bandwidth + pool)
    - Distributed Radio Resource Usage Optimization (muti RAT, multi homing)
    - Bandwidth sharing between operators
      - CAB: Coordinated Access Band (pool)
      - Border games, trade-off range/capacity
      - Coordinated or uncoordinated Interference Management

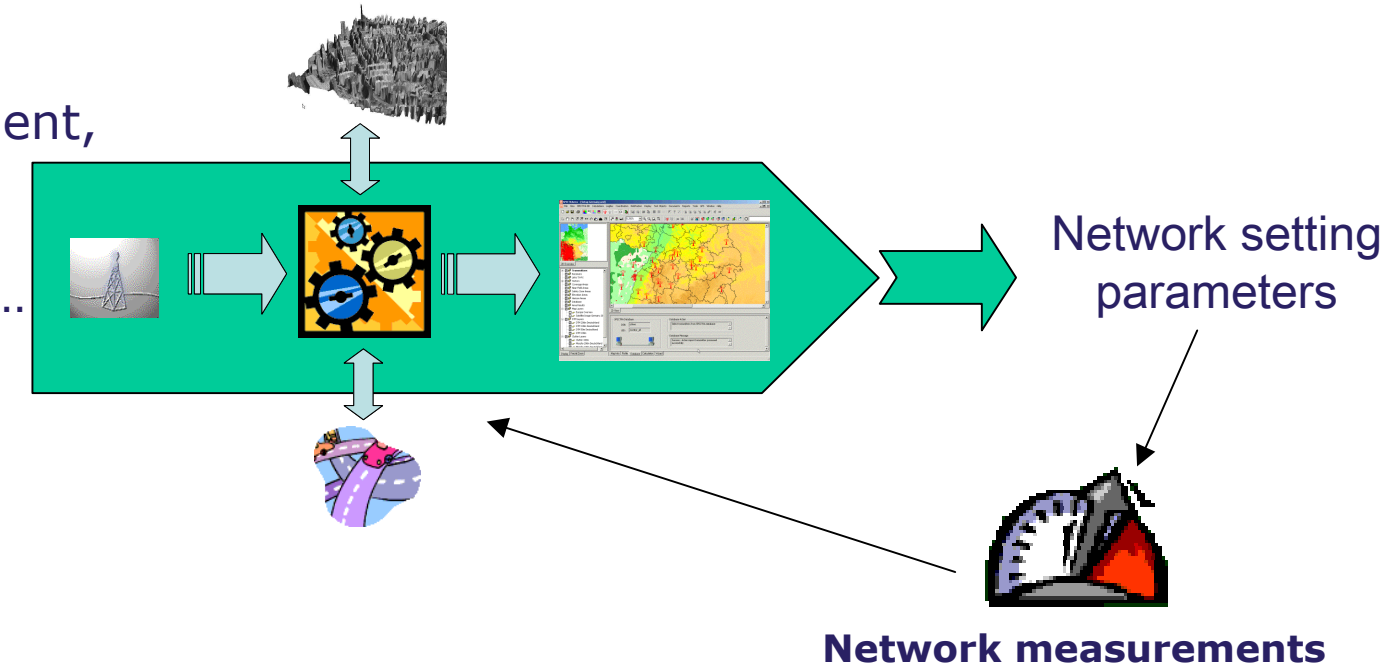
Simulator: Towards a Spectrum Management Tool

- Emerging dynamic spectrum management & cognitive radio systems
- States & Regions (like Paris region) involved:
  - Economical growth
  - Exceptional event or crisis management
  - White spaces
  - Landscape
- An issue for State/Regions regulations and new tools
  - Non exclusive use (sharing) vs. protection of investments (FCC block D)
  - Spectrum management and disseminated sensing for safety of usage

Simulator: Towards a Spectrum Management Tool

bjectives Constraints

QoS,
Security,
Economic Development,
Revenues,
Regulation,
Urban landscape…



Adjust the spectrum usage to needs