Research Session – ISART 2010

1:15p – 3:15p

Session targets:

1. Overview on on-going Cognitive Radio research worldwide.
   - Europe FP7: Roberto Llorente (Technical University at Valencia)
   - UK: Maziar Nekovee (British Telecom)
   - Asia-Pacific: Tan Geok Leng (Infocomm Development Authority, Singapore)
   - USA: Jeff Reed (Virginia Tech.)
   - USA: Lei Yang, Heather Zheng (UC Santa Barbara)

2. Identify common roadblocks and strategies

3. Foster further collaboration through research programs
Spectrum sharing and coexistence: Europe’s 7th Framework Program approaches

ISART 2010, Boulder, CO
July 2010
Overview

- **Introduction**
- **Project Highlights**
  - **E-UWB:** Coexisting Short Range Radio by Advanced Ultra-Wideband Radio Tech.
  - **SENDORA:** SEnsor Network for Dynamic and cOgnitive Radio Access
  - **E3:** End-to-End Efficiency
  - **OneFit:** Opportunistic networks and Cognitive Management Systems for Efficient Application Provision in the Future InterneT
  - **QoSMOS:** Quality of Service and MObility driven cognitive radio Systems
  - **UCELLS:** UWB real-time interference monitoring and CELLular management Strategies
  - **FIVER:** Fully-Converged Quintuple-Play Integrated Optical-Wireless Access Architectures
- **Standardisation and Regulation**
  - **WALTER:** Wireless Alliances for Testing Experiment and Research
- **Conclusion**
Introduction

- Cognitive Radio is the way forward
  - Interesting for coexistence with licensed services (DFS-Radar, DSA-LMR, etc.)
  - Necessary in un-licensed wireless

Just an example..

Router-computer distance was 2-meters and it was 1 am time(!)
More and more unlicensed radio-enabled devices are present day after day

Typical devices..

Not so typical..

Emerging problem: guaranteed bitrate-demanding equipment

Internet TV
- SD
- HD (720)
- HD (1080p)
- 3D
- 3D-AUTOSTEREO (no glasses)
**Introduction**

Cognitive Radio (CR) targets to..

A) **Maximise spectrum capacity**

B) **Enable QoS policy**

- A) Of course!- spectrum capacity is an major economic force
- B) **QoS policies are key factors** to enable operator revenue
  - From “communist” spectrum access (equal for all), to “market” access (“premium services” are possible)
  - QoS policies enable advanced services enter the market
    - (3D HD streaming, on-demand GAMING, on-demand computing)

CR requires a major technological effort to solve roadblocks:

1. Techniques/algorithms
2. Security issues
3. Cost - Cost drives technical choices
4. Standardization/regulation
Europe is devoting major resources to ICT in the 7th Framework Research Program.

**ICT Work Programme 2011-12**

- Total available budget: € 2.4 billion ($ 3.1 Billion 2011-12)
- 8 Challenges + FET
- Challenge 1 represents a major share (≈ 25%)
- Future Internet - 2 strands under Challenge 1

**Mainstream research**

- Continuity with new aspects
  - Future networks, networked media, sensor platforms, services & clouds, trust & security, FIRE experimentation, ...

**FI-PPP**

- Closing the gap between research and innovation
An important share is devoted to ICT. Open calls (announced 20\textsuperscript{th} July):

- FP7-2011-ICT-Fi. Deadline: 2-XII-2010. Funding 90 M\(€\)
- FP7-2011-ICT-GC. Deadline: 2-XII-2010. Funding 30 M\(€\)
- FP7-ICT-2011-FET-F. Deadline: 2-XII-2010. Funding 10 M\(€\)
- FP7-ICT-2011-C. Deadline: 12-III-2013. Funding 46 M\(€\)
- FP7-ICT-2011-EU-RUSSIA. Deadline: 14-IX-2010. Funding 4 M\(€\)

¿Can USA (also other countries) companies/institutes participate in FP7?
- Yes, if European branch with \textbf{R&D capabilities}
- Yes, in specific calls. E.g.
  Support Actions, Networks of Excellence
  Alternative Paths to Components and Systems
  New paradigms for embedded systems
  (etc..)
- Yes, if foreign partner provides \textbf{key technology not found in Europe}
- (if none of the above) Yes, but without R&D funding
Overview

- Introduction
- Project Highlights
  - SENDORA: SEnsor Network for Dynamic and cOgnitive Radio Access
  - E3: End-to-End Efficiency
  - OneFit: Opportunistic networks and Cognitive Management Systems for Efficient Application Provision in the Future InterneT
  - QoSMOS: Quality of Service and MObility driven cognitive radio Systems
  - UCELLS: UWB real-time interference monitoring and CELLular management Strategies
  - FIVER: Fully-Converged Quintuple-Play Integrated Optical-Wireless Access Architectures
- Standardisation and Regulation
  - WALTER: Wireless Alliances for Testing Experiment and Research
- Conclusion
EUWB is an Integrated Project (IP) focused in UWB radio, targeting:

- Identify advanced UWB application scenarios
- Investigate interferers and interference impact on UWB deployment
- Future UWB requirements - coexistence
- CR-UWB [e.g. Detect and Avoid (DAA)]
- Spectrum sensing: non-data aided techniques
- Cognitive pilot channel (CPC): data-aided techniques
- Distributed Cognitive pilot channel
- Overall requirements of CPC
EUWB: Advanced UWB systems toward industries

- To provide sophisticated new highly demanded in several European key industrial application enabled by Advanced Ultra-Wideband Radio Technology (UWB-RT)
  - Home cluster - Philips
  - Automotive cluster- Bosch
  - Public transport cluster - EADS
  - Heterogeneous cluster - Telefonica
Some example of applications
- Real time location and tracking
- Multimedia (audio and video) communications
- Internet services (VOIP, web surfing, etc)
- Personal area communications
- Real time video transmission and fire-fighter localization
- etc.

Application requirements:
- Low data rate with long and medium distance
- Very high and high data rate standard with short and medium distance

UWB Systems Every Where !!!:
- Home, office, car, road and vehicles, emergency, air bus, shopping mall, hospital, industry, etc collocated with other systems

UWB will be spectrally overlapped with other radio systems
Interferers at UWB systems

Recognized interfering signals (In-Band wireless standard):
- WiFi, IEEE 802.11 a/n
- WiMax, IEEE 802.16 d/e
- IEEE 802.15.4a (impulse radio, UWB LDR)
- ECMA 368
- Radar Communications

Out-band wireless standards:
- UMTS
- HSPA/HSDP
- etc.

Future wireless standards:
- IMT advanced
- LTE
- etc

Unrecognized interfering signals:
- Microwave ovens, general electromagnetic interference and any other transmitted signal (e.g. TV broadcasting)

Potential interference impact on UWB system
Interference impact on UWB systems deployment!!

- UWB roadmap
- Worldwide regulation

UWB worldwide common frequency bands:

- 3.1 GHz
- 4.2-4.8 GHz
- 7.25-8.5 GHz
- 10.6 GHz

Source: WiMax Forum

Future requirements UWB systems!!
Potential UWB coexistence and interference mitigation techniques

- Detect and Avoid (DAA)
  - What is DAA?!!
  - DAA technique is mandated by regulation bodies
  - Exiting techniques must be updated to comply with DAA
  - ETSI is going to perform DAA compliance test
- Soft-spectrum adaptation and waveform design
- Spectrum sculpting
- Bi-orthogonal multiple-tone schemes
- Cognitive signalling

Detect and Avoid ➔ Cognitive Radio ➔ Cognitive Signalling
Overview

- Introduction
- Project Highlights
  - **E-UWB**: Coexisting Short Range Radio by Advanced Ultra-Wideband Radio Tech.
  - **SENDORA**: SEnsor Network for Dynamic and cOgnitive Radio Access
  - **E3**: End-to-End Efficiency
  - **OneFit**: Opportunistic networks and Cognitive Management Systems for Efficient Application Provision in the Future InterneT
  - **QoSMOS**: Quality of Service and MObility driven cognitive radio Systems
  - **UCELLS**: UWB real-time interference monitoring and CELLular management Strategies
  - **FIVER**: Fully-Converged Quintuple-Play Integrated Optical-Wireless Access Architectures
- Standardisation and Regulation
  - **WALTER**: Wireless Alliances for Testing Experiment and Research
- Conclusion
Motivation: radio spectrum is a scarce resource that is paradoxically under-utilized.

Objective: develop a technology able to reuse licensed but unused spectrum in an opportunistic manner, in frequency-planned environments.

Challenge: detect and use spectrum holes, without interfering harmfully with the licensed network, with fine granularity of allocation in time and frequency.
FP7 views

SENDORA concept consists in studying and developing a "Sensor Network aided - Cognitive Radio" technology.

Target scenario: provide cognitive nomadic broadband communications in urban areas.
SENDORA implementation follows a system design approach towards system simulations and demonstrations, and including techno-economical studies:
Overview

- Introduction
- Project Highlights
  - SENDORA: SEnsor Network for Dynamic and COgnitive Radio Access
  - E3: End-to-End Efficiency
  - OneFit: Opportunistic networks and Cognitive Management Systems for Efficient Application Provision in the Future InterneT
  - QoSMOS: Quality of Service and MObility driven cognitive radio Systems
  - UCELLS: UWB real-time interference monitoring and CELLular management Strategies
  - FIVER: Fully-Converged Quintuple-Play Integrated Optical-Wireless Access Architectures
- Standardisation and Regulation
  - WALTER: Wireless Alliances for Testing Experiment and Research
- Conclusion
Objectives and Goals of $E^3$

- **Goal**: To transform current wireless system infrastructures into an integrated, scalable and efficiently managed Beyond-3rd-Generation (B3G) cognitive system framework, which ensures seamless access to applications and services and exploits the full diversity of corresponding heterogeneous systems.

- **Introduce cognitive systems in the wireless world**

---

**Cognitive Radio System design** exploiting the capabilities of reconfigurable networks and self-adaptation to a dynamically changing environment.

- **Objective 1**: Gradual, non-disruptive evolution of existing wireless networks in accordance to user requirements.

- **Objective 2**: Increased efficiency of wireless network operations, in particular by optimally exploiting the full diversity of the heterogeneous radio eco-space: Increase system management efficiency for network operation and (re-) configuration building on cognitive system and distributed self-organisation principles.

Contact: wolfgang.koenig@alcatel-lucent.com, pdemest@unipi.gr
More Information: www.ict-e3.eu
End-to-End Efficiency

Network operators (4)
Equipment manufacturers (6)
Regulators (4)
Bell Labs Germany project coordinator
BUPT
Academia / research institutes (8)
Jan. 08 – Dec. 09
22 Organizations (11 Countries)
Resources: 1413 PM (~59 PY/Y)

Telefonica
Telecom Italia
&France Telecom
Telecom Italia
Bundesnetzagentur
Agence Nationale des Fréquences
Fraunhofer
Institut für Offene Kommunikationssysteme
NATIONAL & KAPODISTRIAN UNIVERSITY OF ATHENS
IDATE Consulting & Research
Vrije Universiteit Brussel
University of Surrey
University of Piraeus
BUPT

RAS
Cognitive Radio System Features

- Cognitive Radio Network supporting:
  - Full exploitation of Heterogeneous access systems with Joint Radio Resource Management
  - Flexible, more efficient spectrum management
  - Self-X functionality, Knowledge based, self-learning
  - Autonomous or collaborative decision making
  - Reconfigurable and dedicated terminals
  - Flexible Multistandard Basestation
  - Dynamic Spectrum Access

- Therefore improved performance and capacity – reduced OPEX

![Diagram](image)  
**Fig. 1.** Dynamic reconfiguration to an optimal RAT distribution profile.
Innovation brought about by the project

Enablers
- Cognitive Pilot channel (CPC)
- Spectrum Sensing
- Cognitive Control Radio

Prototype
- The E³ prototyping environment
- Demonstration Scenarios

Standardisation Work
- ETSI
- IEEE
- SDR Forum

Regulation Work
- Influence on regulation (ITU-R, CEPT)
Mapping of functional architecture on the LTE network architecture

Impact on network elements
- Base Stations
- Terminals
- Gateways and core network elements
- Operation and management domain

Impact on interfaces
- Standard interfaces enhanced
- Additional content identified
- Contributions to standardisation

Studies reveal acceptable impact in terms of signalling load (for example [1]) and processing power for the support of the additional functionality

Enablers: cognitive pilot channel (CPC) – cognitive control radio (CCR)

- CPC for transferring information among networks and terminals in a cognitive network context
- Technical approach
  - Information specification
  - Mapping to outband and inband
  - Bit-rate calculations
  - Mesh optimisations
- CCR for direct communications of cognitive networks in limited spectrum band
  - Unlicensed access
  - Lightly licensed access
    - Primary systems may be present
  - Very low power consumption
Overview

- Introduction
- Project Highlights
  - SENDORA: SEn sor Network for Dynamic and cOgnitive Radio Access
  - E3: End-to-End Efficiency
  - OneFit: Opportunistic networks and Cognitive Management Systems for Efficient Application Provision in the Future InterneT
  - QoSMOS: Quality of Service and MObility driven cognitive radio Systems
  - UCELLS: UWB real-time interference monitoring and CELLular management Strategies
  - FIVER: Fully-Converged Quintuple-Play Integrated Optical-Wireless Access Architectures
- Standardisation and Regulation
  - WALTER: Wireless Alliances for Testing Experiment and Research
- Conclusion
“The main objective of the project is to design, develop and validate the concept of applying opportunistic networks and respective cognitive management systems for efficient application/service/content provisioning in the Future Internet”
Motivation for OneFIT

Applications
- Growing interest for more application areas (FI penetrating every facet of our lives)
- Social networking and prosumer concepts, communication and entertainment, management of critical infrastructures, environment (eco-system) protection, product manufacturing, digital services

Diversification
- Information flows, area and time of provision, end points can be users or machines, communication types
- Quality of Service – Quality of Experience
- Networks under stress for resources

Efficiency in resource provision
- Worst–case based planning, leads to over–provisioning of resources in non–peak times.
- Intelligent resource management (e.g., spectrum reuse) is a solution, e.g., recent step is the addition of WiFi access points and femtocell nodes.
- User expectations increase and so do the resource requirements posed onto communication networks.
- Quest for further efficiency in resource provisioning.
- Efficiency coupled with: (i) the higher utilization of resources; (ii) the reduction of transmission powers and energy consumption (in general, having decisions with a “green” footprint); (iii) the reduction of the total cost of ownership, which will be assumed to comprise the operational expenditures (OPEX), capital expenditures (CAPEX), and costs associated with the management of customer relations.

FI era requirements:
- Applications: numerous, diversified, often characterized by a “localized” interest
- QoE/QoS
- Increased need for wireless
- Need for efficiency in application provision
Overview

- Introduction
- Project Highlights
  - **E-UWB**: Coexisting Short Range Radio by Advanced Ultra-Wideband Radio Tech.
  - **SENDORA**: SEnsor Network for Dynamic and cOgnitive Radio Access
  - **E3**: End-to-End Efficiency
  - **OneFit**: Opportunistic networks and Cognitive Management Systems for Efficient Application Provision in the Future InterneT
  - **QoSMOS**: Quality of Service and MObility driven cognitive radio Systems
  - **UCELLS**: UWB real-time interference monitoring and CELLular management Strategies
  - **FIVER**: Fully-Converged Quintuple-Play Integrated Optical-Wireless Access Architectures
- Standardisation and Regulation
  - **WALTER**: Wireless Alliances for Testing Experiment and Research
- Conclusion
QoSMOS: At a glance

- Quality of Service and MObility driven cognitive radio Systems
- Is an FP7 Integrated Project
  - Call 4 objective ICT-2009.1.1; The Network of the Future, part (b): Spectrum-efficient radio access to Future Networks
  - Duration is 36 months from January 2010
- Budget
  - 1198 PMs
  - Total = 14.5M€, EC contribution = 9.4M€
- 15 partners (BT, TEL, CEA, OUULU, TUD, IT, NTUK, AGILENT, TCF, UNIS, NEC, Fraunhofer, TST, ALD, BME
  + External Advisory Board for project steering
    (regulators, broadcasters,..)
- Contact: Michael Fitch; michael.fitch@bt.com
- More information: www.ict-qosmos.eu
To develop a framework to **improve utilisation of radio spectrum**, **consistent with co-existence** with other services and opening up of the mobile broadband value chain,

- A cognitive approach to align with the strategies of the regulators
- A pan-European effort with a range of partners is needed to bring all the pieces together and move them close to market
QoSMOS: Objectives

- The main objective is to provide a set of solutions for efficient radio access to future networks
- Under this are two S & T objectives
  - Cognitive Wireless Access Provision [measurable criteria]
    - Platform aspects
    - Intelligence aspects
  - Network Support Provision [measurable criteria]
- And two non-S & T objectives
  - Use-case development [guidelines on marketing]
  - Preparation of regulatory policies [response of regulators]
QoSMOS: Concept

An upper cognitive manager that allocates resource

A lower cognitive manager that manages the spectrum portfolio
Overview

- Introduction
- Project Highlights
  - **E-UWB**: Coexisting Short Range Radio by Advanced Ultra-Wideband Radio Tech.
  - **SENDORA**: SEnsor Network for Dynamic and cOgnitive Radio Access
  - **E3**: End-to-End Efficiency
  - **OneFit**: Opportunistic networks and Cognitive Management Systems for Efficient Application Provision in the Future InterneT
  - **QoSMOS**: Quality of Service and MObility driven cognitive radio Systems
  - **UCELLs**: UWB real-time interference monitoring and CELLular management Strategies
  - **FIVER**: Fully-Converged Quintuple-Play Integrated Optical-Wireless Access Architectures
- Standardisation and Regulation
  - **WALTER**: Wireless Alliances for Testing Experiment and Research
- Conclusion
- UCELLS targets ultra-low power radio sensing and managing
  - New power-efficient radio transmission systems (e.g. UWB)
  - Cognitive radio clusters and advanced radio architectures
  - Security, public safety and emergency application scenarios
    - (e.g. people localization in disaster areas)
UCELLS main TARGET: **UWB sensing to enable cellular UWB**

- Spectral management of UWB signals
- Power-flow control techniques introduction in UWB terminals

**Enabling TECHNOLOGY:** UWB wireless spectrum monitoring is possible by *multichannel high-performance photonic ADC (PhADC)*

Photonics enables...

1. UWB interference mitigation (required for range extension): 3D evaluation of external interference produced
2. Identification and monitoring of wireless interferers disturbing

... because PhADC gathers UWB spectrum information simultaneously from a set of sensors
Scenarios: UCELLS deployment

Mitigation:
3D outgoing interference estimation

Coexistence and security:
3D incoming interference monitoring

UCELLS interference monitoring

CELLULAR UWB COVERAGE AREA
- UWB communication (ECMA-368) are actually:
  1. Fingerprinted
  2. Localized
  3. Managed
Experimental results

- Fingerprinting

<table>
<thead>
<tr>
<th>Time</th>
<th>dB</th>
<th>dB</th>
<th>dB</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-100DB</td>
<td>-100DB</td>
<td>-100DB</td>
</tr>
<tr>
<td>1</td>
<td>-100DB</td>
<td>-100DB</td>
<td>-100DB</td>
</tr>
<tr>
<td>2</td>
<td>-100DB</td>
<td>-100DB</td>
<td>-100DB</td>
</tr>
<tr>
<td>3</td>
<td>-100DB</td>
<td>-100DB</td>
<td>-100DB</td>
</tr>
<tr>
<td>4</td>
<td>-100DB</td>
<td>-100DB</td>
<td>-100DB</td>
</tr>
<tr>
<td>5</td>
<td>-100DB</td>
<td>-100DB</td>
<td>-100DB</td>
</tr>
<tr>
<td>6</td>
<td>-100DB</td>
<td>-100DB</td>
<td>-100DB</td>
</tr>
<tr>
<td>7</td>
<td>-100DB</td>
<td>-100DB</td>
<td>-100DB</td>
</tr>
</tbody>
</table>

- Localization

Sensor 1

Sensor 2

Sensor 3

Sensor 4

Sensor 5

Estimated

Real

Sensor 4

40 cm

Sensor 5

Sensor 2

Sensor 1

Sensor 3
Overview

- Introduction
- Project Highlights
  - SENDORA: SEnsor Network for Dynamic and cOgnitive Radio Access
  - E3: End-to-End Efficiency
  - OneFit: Opportunistic networks and Cognitive Management Systems for Efficient Application Provision in the Future Internet
  - QoSMOS: Quality of Service and MObility driven cognitive radio Systems
  - UCELLS: UWB real-time interference monitoring and CELLular management Strategies
  - FIVER: Fully-Converged Quintuple-Play Integrated Optical-Wireless Access Architectures
- Standardisation and Regulation
  - WALTER: Wireless Alliances for Testing Experiment and Research
- Conclusion
1. QUINTUPLE PLAY implemented using FULL STANDARD RECEIVERS (UWB, WiMAX, LTE and OFDM-baseband) employed at customer premises – ALL OFDM-BASED

2. COGNITIVE FIBRE-TO-THE-HOME NETWORK

3. Two architectures: CWDD: Conventional wavelength duplexing architecture
   RWDD: R-EAT based (only optical source at CO)
Overview

- Introduction
- Project Highlights
  - **E-UWB**: Coexisting Short Range Radio by Advanced Ultra-Wideband Radio Tech.
  - **SENDORA**: SEnsor Network for Dynamic and cOgnitive Radio Access
  - **E3**: End-to-End Efficiency
  - **OneFit**: Opportunistic networks and Cognitive Management Systems for Efficient Application Provision in the Future Internet
  - **QoSMOS**: Quality of Service and MObility driven cognitive radio Systems
  - **UCELLS**: UWB real-time interference monitoring and CELLular management Strategies
  - **FIVER**: Fully-Converged Quintuple-Play Integrated Optical-Wireless Access Architectures
- Standardisation and Regulation
  - **WALTER**: Wireless Alliances for Testing Experiment and Research
- Conclusion
WALTER = Wireless Alliances for Testing Experiment and Research

Objective: Development of an international network of test beds for emerging broadband wireless technologies

Project focus: Coexistence of emerging wireless broadband technologies with other radio technologies and services

Partners:

Duration: 2 years (01.01.2008 to 31.12.2009)

Project website: http://walter-uwb.eu
Overall approach

- Testbed definition
  - Test cases and parameters
  - Test procedures
  - Test setup
  - Test equipment features
Spectral compatibility and co-existence

**Example:** Ultra-Wideband radio

**Spectrum sharing**
Spectral underlay concept

**Interference scenario**
Impact on licensed services

**Mitigation mechanisms**
Detect-and-Avoid (DAA)

**Victim service protection**
Impact on PHY layer and QoS

### Example: Ultra-Wideband radio

- **Civil Radar (L and S band)**
- **Military Radar (X band)**
- **Military Radar (S band)**
- **2.6 3.1 4.8 6.0 9.0**
- **PSD [dBm/MHz]**
- **Frequency [GHz]**
- **Civil Radar (L and S band)**
- **BWA (WIMAX)**
- **WLAN**
- **Military (outdoor)**
- **UWB**
- **10.6**

### Interference scenario
- **Impact on licensed services**
- **Video, Telephony, Data Impaired service**
- **x < P_{thresh1}**
- **x > P_{thresh2}**
- **UWB device**
- **Victim**
- **P_{thresh1} = -61 dBm**
- **P_{thresh2} = -38 dBm**

### Mitigation mechanisms
- **Detect-and-Avoid (DAA)**

### Victim service protection
- **Impact on PHY layer and QoS**

- **Throughput [kbps]**
- **Throughput**
- **CINR [dB]**
- **RSSI [dBm]**
- **Throughput**
- **CINR**
- **55 QAM CTC5/6**
- **55 QAM CTC3/4**
- **55 QAM CTC2/3**
- **16QAM CTC3/4**
- **16QAM CTC1/2**

### Spectrum sharing
- **Spectral underlay concept**

- **PSD [dBm/MHz]**
- **Frequency [GHz]**
- **Civil Radar (L and S band)**
- **Military Radar (X band)**
- **Military Radar (S band)**
- **2.6 3.1 4.8 6.0 9.0**
- **PSD [dBm/MHz]**
- **Frequency [GHz]**
- **Civil Radar (L and S band)**
- **BWA (WIMAX)**
- **WLAN**
- **Military (outdoor)**
- **UWB**
- **10.6**

### Zone 1
- **UWB device**
- **Victim**
- **Zone 2**

### Zone 2
- **P_{thresh1} = -61 dBm**
- **P_{thresh2} = -38 dBm**

### Zone 3
Measurement issues and limitations

**Radiated measurements**
Antenna far-field, path loss, noise

**Signal-to-noise ratio**
Wanted signal power < environmental noise

**Peak power measurements**
Equipment limitations, scaling factor

**Functional verification**
Detect-and-Avoid test procedures
Test Categories

The **WALTER test beds** cover 8 test categories:

- Regulatory (REG)
- Conformance (CON)
- Interoperability (IOP)
- Radiated Performance Tests (RPT)
- Over The Air (OTA)
- Coexistence (COE)
- Performance (PER)
- Plugfests (PGF)

- Spectrum and Power Characteristics
- Radiated Emissions
- Detect and Avoid
- Protocol testing
- and more ...
Overview

- Introduction
- Project Highlights
  - **E-UWB**: Coexisting Short Range Radio by Advanced Ultra-Wideband Radio Tech.
  - **SENDORA**: SEnsor Network for Dynamic and cOgnitive Radio Access
  - **E3**: End-to-End Efficiency
  - **OneFit**: Opportunistic networks and Cognitive Management Systems for Efficient Application Provision in the Future Internet
  - **QoSMOS**: Quality of Service and MObility driven cognitive radio Systems
  - **UCELLS**: UWB real-time interference monitoring and CELLular management Strategies
  - **FIVER**: Fully-Converged Quintuple-Play Integrated Optical-Wireless Access Architectures
- Standardisation and Regulation
  - **WALTER**: Wireless Alliances for Testing Experiment and Research
- Conclusion
Presented Europe FP7 program – open to collaborate with USA companies/institutions

Cognitive Radio is under major research TODAY – expect outcome tomorrow

Presented different initiatives..
  ◦ From high-level CR management
  ◦ To low-level radio sensing
  ◦ Standardization
  ◦ Regulation

RLLORENT@NTC.UPV.ES

More information can be found in the RADIO ACCESS AND SPECTRUM (RAS) FP7 Cluster: http://www.newcom-project.eu/ras
Further Contact

- **E-UWB:**
  Dr. Abdur Rahim (abdur.rahim@create-net.org)
  Dr. Radoslaw Piesiewicz, WCB EIT + Sp.z.o.o., Poland
  Prof. Sven Zeisberg (zeisberg@htw-dresden.de)
  http://www.euwb.eu

- **SENDORA:**
  Dr. Bertrand Mercier (Bertrand.MERCIERB@fr.thalesgroup.com)
  http://www.sendora.eu

- **E3:**
  Mr. W. Koenig (Wolfgang.Koenig@alcatel-lucent.com)
  Prof. P. Demestichas (pdemest@unipi.gr)
  https://ict-e3.eu/

- **OneFIT:**
  Prof. P. Demestichas (pdemest@unipi.gr)
  J. Gebert (Jens.Gebert@alcatel-lucent.com)
  http://www.ict-onefit.eu

- **QuOSMOS**
  Dr. Michael Fitch (michael.fitch@bt.com)
  http://www.ict-qosmos.eu

- **UCELLS, FIVER**
  Prof. Roberto Llorente (rllorent@dcom.upv.es)
  http://www.ict-ucells.eu
  http://www.ict-fiver.eu

- **WALTER**
  Detlef Fuehrer (detlef.fuehrer@jrc.ec.europa.eu)
  http://walter-uwb.eu