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An over-the-air reconfiguration API for cognitive radio testbeds

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Outline

- Cognitive Radio
- Brief introduction to over-the-air reconfiguration
  - What is it?
  - How does it fit into the CR context?
- Implementation
  - Requirements of a CR testbed
  - Soft- & Hardware
- Results
  - Component Integration
  - Example meter (sensor)
- Demonstration
COGNITIVE RADIO
Cognitive Radio – In a nutshell

- 2000: Mitola coins the term *Cognitive Radio* in his Ph.D. thesis
- Cognitive Radio according to Mitola
  - User centric
  - Intelligent
  - Adaptive
- A fusion of
  - SDR
  - Sensors / Awareness
  - Artificial Intelligence
SHORT INTRO TO OVER-THE-AIR RECONFIGURATION
Over-the-air-reconfiguration - Introduction

Components
- Multiple radio terminals
  - Master
  - Slave
- Common (known) waveform

Components
- Master decides to change waveform
- Two cases:
  - Both terminals know the waveform
    - Transmit parameters
  - Only one terminal knows the waveform
    - Transmit waveform

Problem
- Adding new components at runtime
# Over-the-air reconfiguration – Security

## Source code
- Transmitted source code needs privileges (hardware access)

## Transmission over the air
- Data integrity
- User authentication
- Possibly secrecy

## Solution
- Run different parts of the system in separate processes
- Cryptography
  - Hash functions
  - Digital Signatures
Over-the-air reconfiguration – CR context

<table>
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<th>Often neglected</th>
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<tr>
<td>- For Communications we need at least two terminals</td>
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<tr>
<th>CR autonomously selects waveforms</th>
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<td>- Partner needs to be notified</td>
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<td>→ OTAR becomes necessary</td>
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<tr>
<th>CR autonomously creates waveforms</th>
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<td>- Decisions are based on knowledge (History, Environment)</td>
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<td>- The developed waveforms differ!</td>
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<td>→ OTAR becomes necessary</td>
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IMPLEMENTATION
## Implementation – Requirements Analysis

### Security
- Data integrity
- User authentication

### Scalability
- Adding new components has to be simple
  - Meters / sensors
  - Artificial intelligence
  - RF frontend

### Flexibility
- Run different parts in separate processes
- Try to avoid limitations imposed on new components
  - Programming language
  - Operating system
## Implementation – Software used

### GNU Radio
- Signal Processing Framework
- Free Software
- Mostly PHY Layer
  - Integration of RF Frontend
  - Modulator / Demodulator

### GNU Privacy Guard
- Framework for cryptography (RSA, AES, SHA-1…)
- Free Implementation of RFC 4880
- Cross Platform

### D-Bus
- „low-latency, low-overhead, easy to use IPC“
- Part of the freedesktop.org project
- RPC, Signals, Asynchronous Programming
Implementation – Component Integration

Overview

- Two domains
  - CR
  - Environment
- Connections via D-Bus

- Cognitive Engine not implemented
- Reconfiguration Controller
  - configures SDR
  - Protocol for reconfiguration
Implementation – Reconfiguration Controller

Protocol Parser
- Contains Protocol
  - simple, line based
  - FSM
- exchangeable

Module Manager
- Availability of the modules / waveforms
- Security
  - Signatures
  - Hashes

Reconfiguration Controller

Protocol Parser
- check availability
- add
- get module

Module Manager (Master)
- current waveform

Module Manager (Slave)*
- * dashed parts only used in Master configuration

start / stop / exchange

check availability

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RESULTS
Results

- Components
  - Framework
    - Testing and implementing CR Terminals
    - Easy integration of new components
    - Waveforms can be developed in GNU Radio

- Demonstrator
  - OTAR Reconfiguration
  - Three example waveforms
    - Audio streaming
    - Video streaming
    - Narrowband FM
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Q&A / Discussion