Karlsruhe Institute of Technology

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

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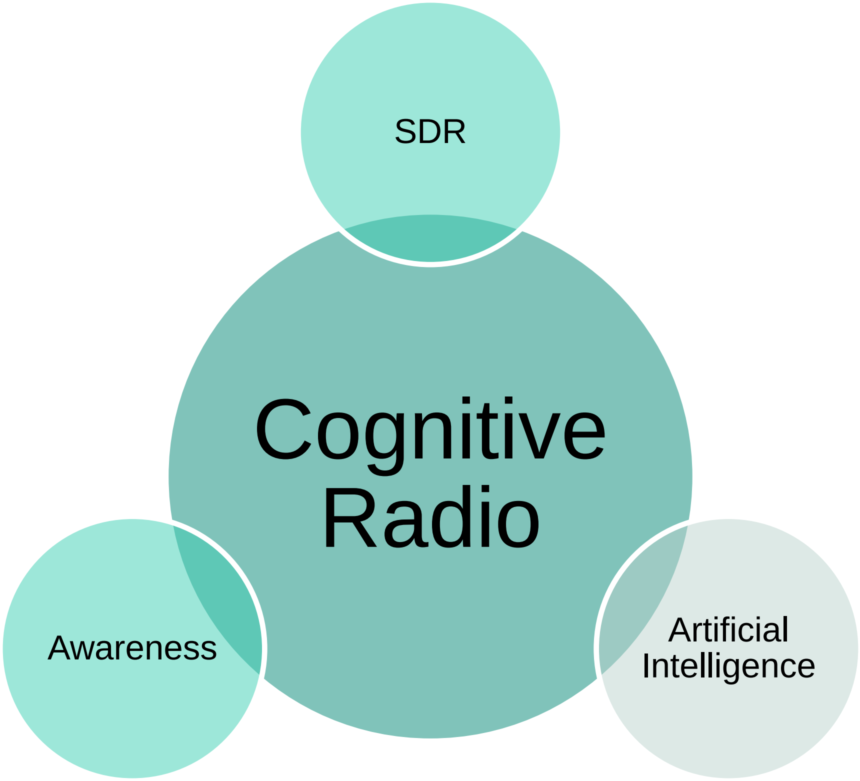
Outline

- 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

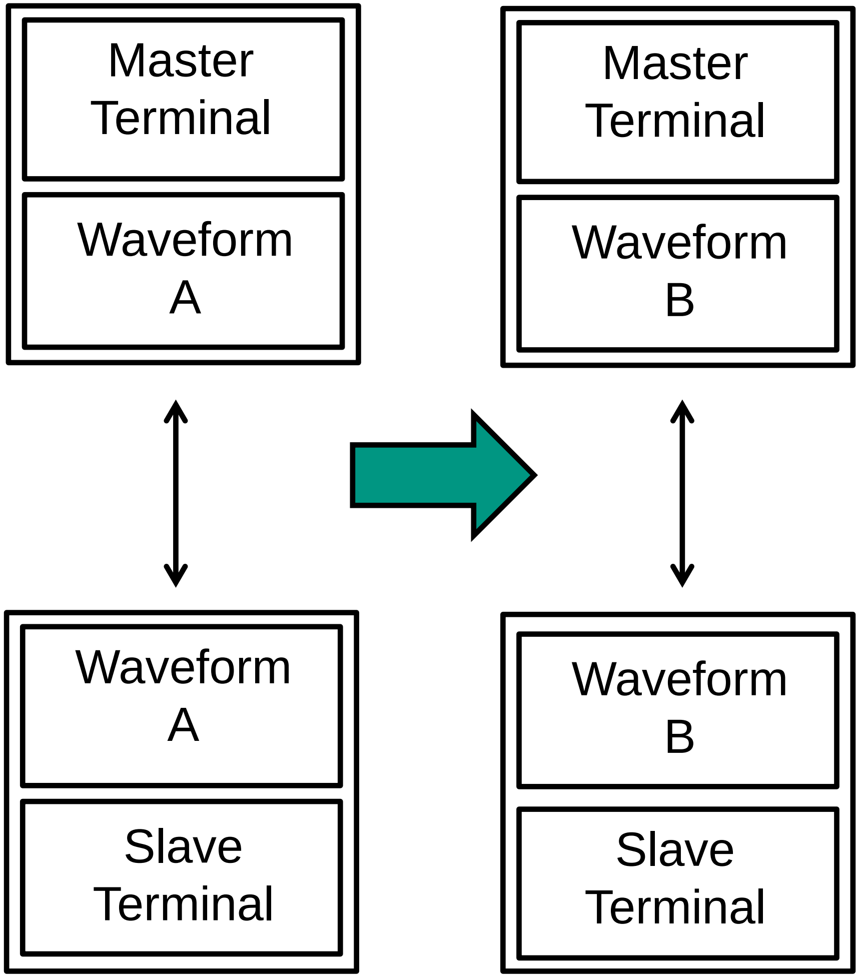
Cognitive Radio – In a nutshell



- 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 authentification
- Possibly secrecy

Solution

- Run different parts of the system in seperate processes
- Cryptography
  - Hash functions
  - Digital Signatures

Over-the-air reconfiguration – CR context

Often neglected

- For Communications we need at least two terminals

CR autonomously selects waveforms

- Partner needs to be notified

→ OTAR becomes necessary

CR autonomously creates waveforms

- Decisions are based on knowledge (History, Environment)
- The developed waveforms differ!

→ OTAR becomes necessary

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

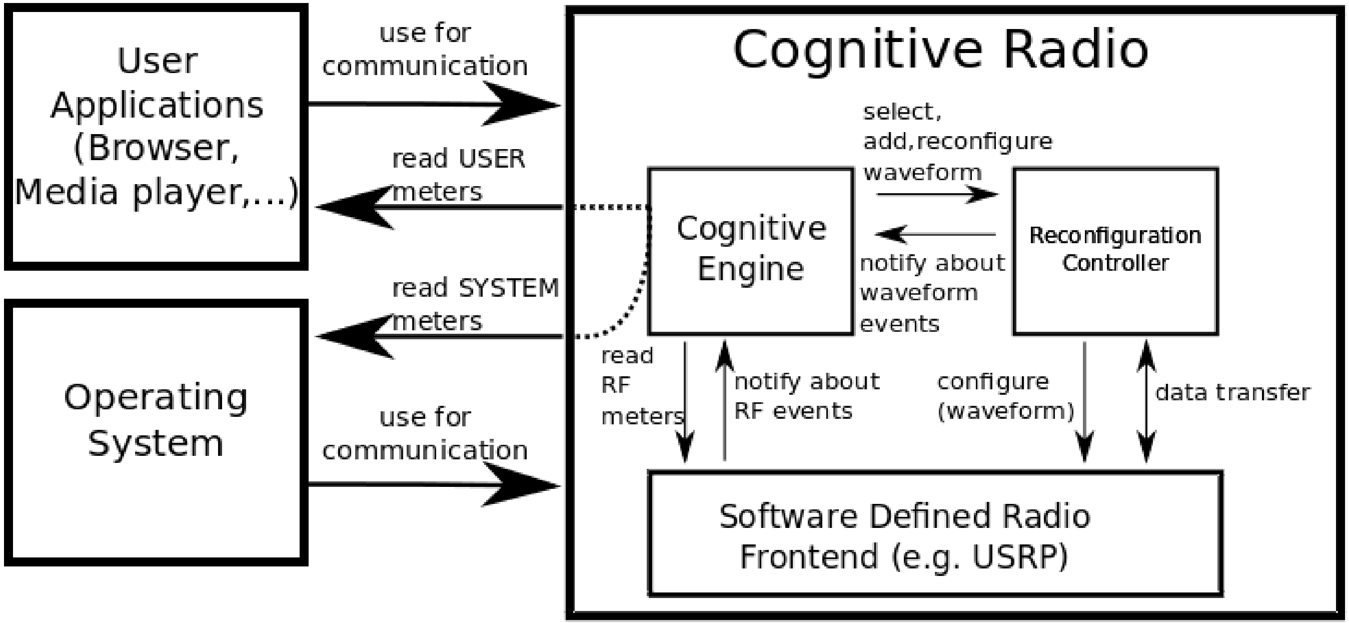
GNU Privacy Guard

- 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

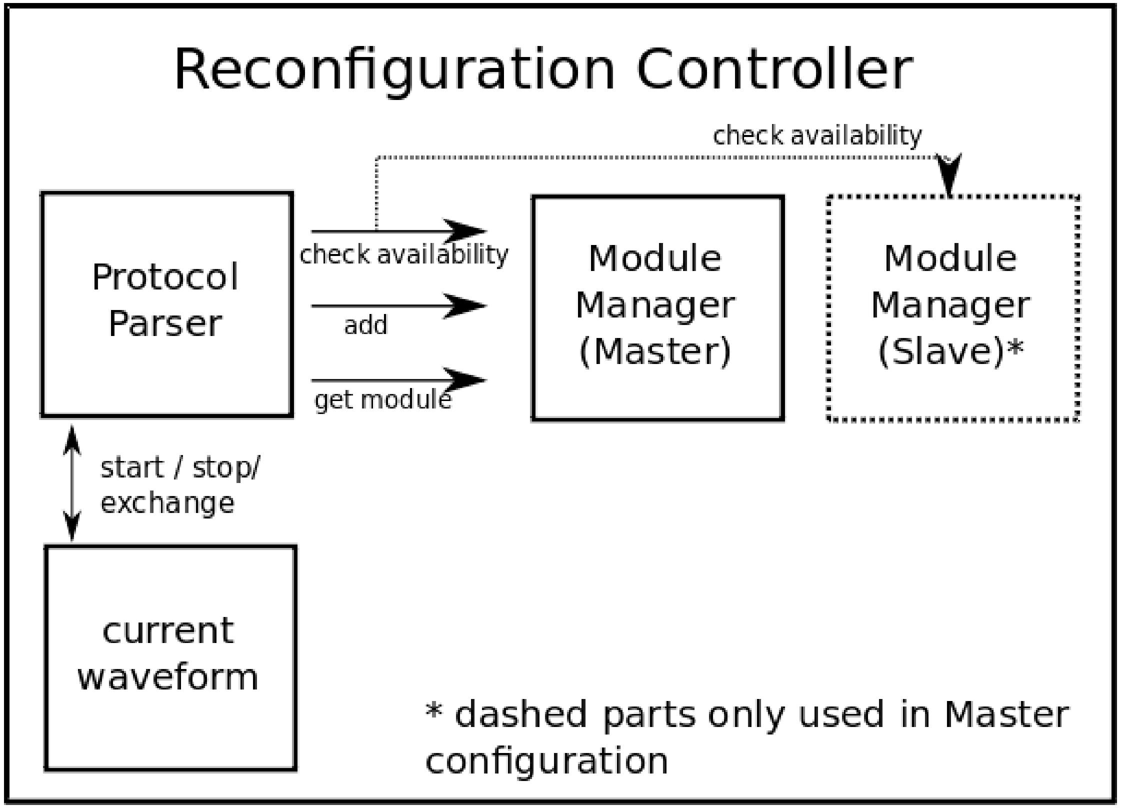
Implementation – Reconfiguration Controller

Protocol Parser

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

Module Manager

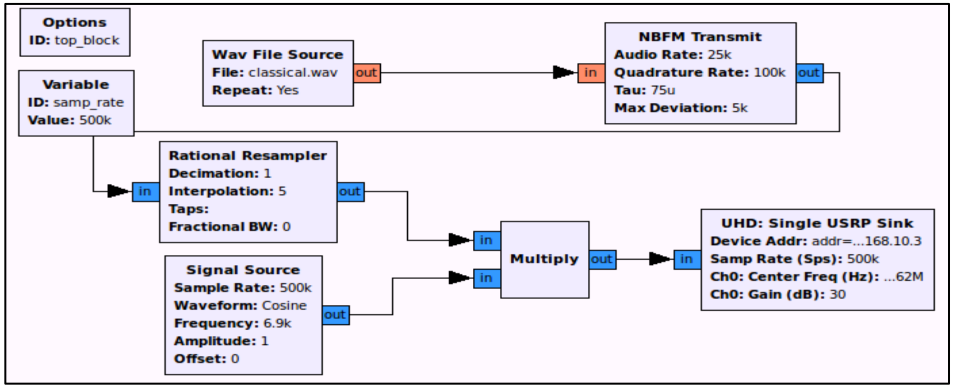
- Availability of the modules / waveforms
- Security
  - Signatures
  - Hashes



* dashed parts only used in Master configuration

RESULTS

Results



Options
ID: top_block

Variable
ID: samp_rate
Value: 500k

Wav File Source
File: classical.wav
Repeat: Yes

NBFM Transmit
Audio Rate: 25k
Quadrature Rate: 100k
Tau: 75u
Max Deviation: 5k

Rational Resampler
Decimation: 1
Interpolation: 5
Taps:
Fractional BW: 0

Signal Source
Sample Rate: 500k
Waveform: Cosine
Frequency: 6.9k
Amplitude: 1
Offset: 0

Multiply

UHD: Single USRP Sink
Device Addr: addr=...168.10.3
Samp Rate (Sps): 500k
Ch0: Center Freq (Hz): ...62M
Ch0: Gain (dB): 30

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

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