The Nucleus Approach: Efficient Development of Portable Wireless Communication Transceivers

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Software Defined Radios (SDRs) are an attractive solution to cope with the flexibility of mobile wireless communication devices in future. The main idea is to implement functions in software that have been previously integrated as hard-wired logic circuits. Initial results of available SDR platforms highlight the large potential, but also their limitations. In particular, the limited energy budget for mobile telecommunication devices creates a huge barrier for SDR approaches, which need to be addressed carefully by specific design optimizations. Another limitation is that software development has to deal with low-level hardware details in order to achieve the required performance. Unfortunately, this limits the portability of radio standards as the software becomes platform dependent. Addressing this issue, the Nucleus methodology [1, 2] has been created that covers the key issues of SDR development, namely novel algorithms, hardware architectures and tooling.

In this poster we present the Nucleus methodology and the related tooling. Furthermore we present how it can be applied to a MIMO OFDM transceiver that has been developed under grant FP7-248716-2PARMA.

References


**Cognitive & Energy Efficient Wireless Communication Transceiver Design**

### Cognitive Wireless Networks and Radios:
- Must sense or be cognitive of the environment
- Other user interference, multi-path, noise, etc.
- Time-variations
- Must be intelligent to analyze the situation and find the optimal communications protocol, frequency band, transmission mode, etc.
- Must reconfigure
- And constantly adapt to changing mobile environments

Find the best protocol, frequency band, and transmission mode.

### Software Defined Radios:
- SDRs provide the required flexibility, hence are the main enabler of cognitive radios and networks
- Energy efficiency and challenging performance requirements demand
  Heterogeneous Multi-Processor System-on-Chip architectures.

### Design Issues and Project Goals
- **Goals:**
  - Identify novel methodology and develop tools for design of future SDRs & CRs
  - Find efficient and flexible architecture implementations
  - Investigate algorithms that enable efficient architectures

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**Tools**

**Novel Design Methodology**

- Transceiver Description
- Nucleus Library
- Mapping & Evaluation
- Board Support Package
- HW Platform

- Tool Flow Implementation
- Advanced Simulation Techniques

**Algorithms**

**Performance vs. Complexity**

- Physical-Layer:
  - Most standards specify a minimum required error rate performance
  - **Standard**
    - DVB-T
    - 2x10⁻⁴ coded BER
    - 802.16
    - 10⁻⁴ coded BER
  - Achieving an error rate better than the specified is not necessary.
  - Investigate trade-offs between algorithm complexity and energy efficiency for achieving the necessary performance constraints.

- Example MIMO Demapper:
  - Efficient algorithms: Min. complexity (error rate) for certain error rate (complexity)
  - ZF: zero forcing
  - MMSE: minimum mean-squared error
  - OSIC: ordered successive interference cancellation
  - SD: sphere decoder
  - ES: exhaustive search

**Architecture**

- **Future Transceiver Design**
  - Algorithms:
    - sphere decoder
    - channel estimator
    - MAC processing
  - Nuclei: critical, demanding, algorithmic kernel that captures common functionalities within and among transceivers

- Implementations provided by Flavors bundled with Processing Element

- Heterogeneous MPSoC architecture made of efficient, but flexible components (Flavors bundled with PEs).

- This includes investigation of critical functions and their implementations, e.g.
  - X-hundred Mb/s MIMO-OFDM Demapper tape out together with ETH Zürich

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**Cross Disciplinary Research**

- 6 Professors
- around 20 Researchers

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