Designing Terminals and Infrastructure Components for Cognitive Wireless Networks

Admir Burnic, Christoph Spiegel, Alex Vießmann, Arjang Hessamian-Alinejad, Andreas Waadt, Guido H. Bruck, and Peter Jung

*Kommunikations*Technik*, Universität Duisburg-Essen

E-Mail: Arjang.Hessamian@uni-duisburg-essen.de
Contents

• *Software Defined Radio* (SDR) and *Cognitive Radio* (CR)
• Demands on SDR and CR
• Petri Net based implementation of CR
• Generic cognitive wireless protocol structure
• SDR and CR demonstrators
The Software Defined Radio Questions

From Radio Frequency to Baseband:
- Where to put A/D Converters
- How to split Hardware and Software
Software Radio

The Software Radio (SR) concept:
• Communication functions realized as software.
• Several transceiver algorithms running on the same hardware.
• Several communications standards running on the same hardware.

An ideal Software Radio samples the antenna output directly:
Software Defined Radio

The Software **Defined** Radio (SDR) concept:

- SDR is a practical version of a Software Radio (SR).
- Received signals are sampled after suitable band selection filtering and signal down-conversion.
Cognitive Radio

Cognitive Radio (CR) is an SDR that
• senses its environment
• tracks changes
• reacts upon its findings

A Cognitive Radio frequently exchanges information with the networks it is able to access

It should know
• where it is (self-location)
• what it is able to do (self-awareness)
• where the reachable base stations are
Reconfigurable Radio/Software Defined Radio

KommunikationsTechnik’s View on Reconfigurability

**On-line mode**

- Cognitive operation (CO) sensing available communications connections, asking for user interaction if new radio interface operation is desired
- Linking operation (LO) connecting appropriate binary PHY and MAC modules to adapt to the desired new communications connections, validating the new transceiver chain
- Regular operation (RO) operating the communications connections
- Regular operation and prepare (RO&PC) operating the communications connections and preparing for reconfiguration, e.g. update, reconfiguration, handover

**Off-line mode**

- Source code library with optimized source code for the PHY and MAC layer modules of communications standards and modes, e.g. UMTS/CDMA, WiMAX, UWB, Bluetooth, GSM/GPRS, EDGE, IrDA, etc.
- Processor intrinsics library with technology information and information about optimized processor routines
- Binary objects library with binary objects of the PHY and MAC modules, compiled for the wireless processor

Single chip processor (alternatively PCB level integration)

Flash, ROM

On-chip memory
Generic Cognitive Wireless Protocol Structure


- Infrastructure Information
- Network Identification
  - Radio Parameters
- Location Update Request
- Offered Services Request
- Location Information
- Services Information
- Location and Service Information Request
- Location and Service Information Response
- Interference Avoidance Request
- Interference Avoidance Response
- Radio Parameter Update Requests
- Radio Parameter Update Responses
- Access Request
  - Service Request
- Access Grant
  - Service Grant

- Identification Request
- Identification Response
- Location and Service Information Request
- Location and Service Information Response
- Interference Avoidance Request
- Interference Avoidance Response
- Radio Parameter Update Requests
- Radio Parameter Update Responses
- Access Request
  - Service Request
- Access Grant
  - Service Grant
**HAWK - Bluetooth/GSM/DECT Transceiver**

- **Kommunikations Technik**
- **HAWK** - Bluetooth/GSM/DECT Transceiver

**KT Services**
- Scientific and Technical Consultation in PHY, MAC, LLC, and Network Layer Aspects
- Concept Engineering for Communication Equipment and HW/SW Implementations
- Real-Time Demonstrator Realization incl. TI-DSP Firmware Development and Optimization
- Java based Multimedia Application Development and Optimization

**Texas Instruments**

**Concept for multimedia services in mid-range terminals and access points, targeting cellular systems**
- Advanced adaptive signal processing for
  - UTRA/W-CDMA
  - IEEE 802.16e and WiBro
  - Novel Multicarrier/W-CDMA

**Transceiver comprises**
- 1 TI TMS320C6416 DSP
- 1 mixed-signal baseboard
- 1 interface PCB
- 1 Atmel RF board plus 2 antennas
- Firmware and development by KT

**Concept for multimedia services in low-cost terminals and access points, targeting short-range systems**
- Advanced adaptive signal processing for
  - Bluetooth Basic Rate mode
  - Bluetooth EDR mode
  - Also applicable to DECT and GSM

**Transceiver comprises**
- 1 TI TMS320C6713 DSP
- 1 mixed-signal zero-crossing board
- 1 interface PCB
- 1 Atmel RF board plus 2 antennas
- Firmware and development by KT

A multi-Ti-DSP platform for future professional multimedia services with OFDM and developed by KT.
Man Machine Interface is realized by a computer terminal or a touch screen.
Cognitive Radio operation is realized by an ARM1026EJ-S based master controller.
Four transceiver engines HAWK, FALCON, MUSTANG, and ARGOS are supported.
Thank you very much for your courtesy.

Univ.-Prof. Dr.-Ing. habil. Peter Jung
Lehrstuhl für KommunikationsTechnik
Universität Duisburg-Essen
Oststrasse 99
D-47057 Duisburg
Germany

Peter Jung und Guido Bruck
Institut für Kommunikationstechnik IKT
c/o Univ.-Prof. Dr.-Ing. habil. Peter Jung
Siegstrasse 27
D-47051 Duisburg
Germany

www.KommunikationsTechnik.org

+49 (203) 379-2590
+49 (160) 528-2557
+49 (203) 379-3904

Peter.Jung@KommunikationsTechnik.org

www.IKT-DU.de

+49 (173) 686-3272
+49 (160) 528-2557

Peter.Jung@IKT-DU.de
Guido.Bruck@IKT-DU.de
Backups
Reconfigurable Radio/Software Defined Radio
Reconfigurability – Master Controlling /1

Cognitive operation (CO)
Sensing available communications connections, asking for user interaction if new radio interface operation is desired

Regular operation (RO)
Operating the communications connections

Setup operation
Continue without adaptation?

LO valid?

CO
RO
RO&P
**Reconfigurable Radio/Software Defined Radio**

**Reconfigurability – Master Controlling /2**

**Linking operation (LO)**

Connecting appropriate binary PHY and MAC modules to adapt to the desired new communications connections, validating the new transceiver chain

**Regular operation and prepare (RO&P)**

Operating the communications connections and preparing for reconfiguration, e.g. update, reconfiguration, handover

- Setup operation
- Continue without adaptation?
  - yes
  - no
- LO valid?
  - no
  - yes
- RO
  - no
  - yes
- RO&P
  - no
  - yes