C2POWER
Cognitive radio and Cooperative strategies for POWER saving in multi-standard mobile terminals

Jonathan Rodriguez
Paulo Marques
Instituto de Telecomunicações, Portugal
C2POWER Project at a glance

Project Coordinator
Jonathan Rodriguez

Instituto de Telecomunicações
Tel: +351 234 377900
Fax: +351 234 377901

Email: jonathan@av.it.pt
Project website: www.ict-c2power.eu

Duration: Jan. 2010-Dec. 2012 (36 months)
Funding scheme: STREP
Total Cost: €5,14m
EC Contribution: €3,45m

10 Partners – 7 European Countries
2 Manufactures
1 Operator
2 SMEs
1 University
4 Research Institutes
Global warming is now unprecedented

- Rise in temperatures of global average air and oceans
- Widespread melting of snow and ice
- Rising of global average sea levels

The global warming debate shifted

- From: Whether man-made climate change is occurring
- To: What atmospheric levels of Greenhouse Gases (GHG) is acceptable

A clear need for reducing CO₂ or GHG emissions

Ref: SMART 2020 report
Ref: Green Touch
ICT Contributions to CO₂ emissions are low
- In 2007, ICT sector contributed to 2%

Mobile communication technologies contribute to a low percentage of ICT CO₂ emissions
- Mobile Communications produce 9% of ICT CO₂ emissions

Why Green Communications?
- ICT impact is rapidly rising
- 72% increase in CO₂ emissions by 2020 compared to 2007
- The decrease in CO₂ emissions in ICT sector will result in global decrease of CO₂ emissions of other sectors (Estimated 15% reduction)
Requirements

- Demand for higher data rates
- Data rate performance of high mobility speeds
- High signaling overhead
- Need for better multimedia support
- High capital and operational costs
Energy Situation

Increase in energy consumption
• Many researches are addressing energy efficiency on the network side
There is a continuously growing gap between the energy requirements of emerging radio systems and what can be achieved by

- Battery technology evolution
- Scaling and circuit design progress
- System level architecture progress
- Thermal and cooling techniques
C2POWER Solutions

- Short-range cooperation among mobile terminals
- Cognitive vertical handovers
- Context Awareness
- Energy-efficient Reconfigurable Radio Transceivers
- Business models
C2POWER aims at providing solutions for decreasing energy consumption of the wireless communications of multi-standard mobile devices, without jeopardizing the requested quality of services.

C2POWER targets two complementary techniques within the framework of cooperation and cognitive radios:

- Cooperative strategies between mobile devices belonging to a cluster using advanced low power short range communications
- Cognitive handover mechanisms to select the RAT, which offers the best energy efficiency while providing the required quality of service
C2 POWER Objectives II

- Investigate how context information can be used by cooperative strategies to achieve power efficiency at the wireless interface of mobile devices.
- Investigate and demonstrate the potential of cooperative techniques based on advanced short range communications for the goal of power/battery lifetime saving of mobile wireless devices.
- Investigate and demonstrate minimum energy consumption handover procedures and policies between heterogeneous technologies and associated tradeoffs in realistic scenarios.
- Investigate, design and demonstrate energy efficient reconfigurable multi-standard transceivers able to switch from one standard to another according to a power saving strategy.

- Investigate methods and incentives to encourage cooperation and develop attractive business models for the network/service provider (Stimulate and motivate cooperative networking among users and between heterogeneous networks, e.g. financial incentives / bio-inspired reputation mechanisms).
Reference Scenarios

Cooperative cluster in a homogeneous network

Centralized RAT
UMTS, WiFi, WiMax, DVB

Advanced short range
Enhanced Short Range
Cooperative cluster
Distributed, reconfigurable
Low power / High data rate

Cooperative cluster with nodes connected to heterogeneous RATs

Exploiting heterogeneous RATs
Short range Cooperation

- Node discovery
- Context Awareness
- Cluster formation
- Node Selection
- Routing
- Cooperative Relaying

C2POWER Context

LR: Good Channel
LR: Bad Channel

WiFi AP

Good Channel
LR: Good Channel
LR: Bad Channel

SR: Short Range Link
LR: Long Range Link

Cooperative Cluster

WiMedia Cluster member
WiMedia Cluster head
WiMedia/WLAN Multi-mode Relay
Cognitive Handover

- Network discovery (using context)
- Energy efficient HO

![Diagram showing network discovery and handover between WiMAX, WiFi, and LTE networks using C2POWER context.]
Context Awareness

Diagram of Context Awareness:
- Context Provider
- Context Reasoner
- Context Filter
- Context Manager
- Decision Engine
- Implementation

Inputs:
- Configuration Profiles
- Policy Set

Outputs:
- Control information/policies
- Context Information
- Configuration
Reconfigurable Radio Transceivers

Challenges
- Multistandard architecture
- Common operator technique
- Multistandard architecture
- Multistandard PA
- adaptive imp. tuner
- agile antennas
- antenna diversity

Perf. evaluation
Simulations
Simulations (transceiver)
Simulation and prototype (PA)
Simulation
Simulation
Prototype
Prototype

Perf. metrics
Power consumption (Tx, Rx, Idle, Sleep)
Power consumption (Tx, Rx, Idle, Sleep)
Efficiency
Power consumption
Power Consumption
Mean Effective Gain

Flexible BB
Multistandard Baseband

Flexible RF
Multistandard Transceiver

Imp. matching
Tx/Rx Front-End

Antennas
Z

Simulations
Prototype
The Business Model

Lightly loaded
Summary

- Growing gap between energy requirements and battery industries.
- Disruptive techniques for energy saving
  - Context Awareness
  - Short range cooperative communication
  - Cognitive vertical handover
  - Energy efficient reconfigurable radio transceivers
- Business Models and incentives for cooperation
- How can these techniques be integrated with other projects and concepts for global energy saving in Wireless Mobile Networks?
C2POWER Impact

- Context awareness
- Cooperation
- Energy Efficient Handover
- Energy efficient Reconfigurable Radio Transceivers
- Business models for incentives

50% reduction in Energy reduction in multi-standard MTs