Green Terminals for Next Generation Wireless Systems

GREEN-T goal is to overcome the energy trap of mobile systems by investigating and demonstrating energy saving technologies for multi-standard wireless mobile devices, exploiting the combination of cognitive radio and cooperative strategies, while enabling the required QoS performance to support active applications. This notion is further extended by lightweight security approaches, which is a pivotal requirement of future mobile systems.
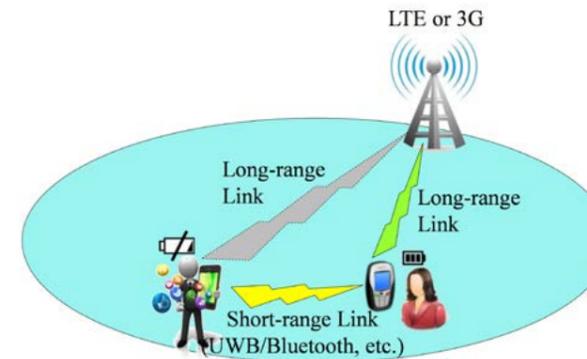

Main Project Team

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Funding Agencies

FCELTIC/ADI	**121,000€**
Start Date	01/07/2011
Ending Date	30/06/2014

Indicators

Journal Papers	6
Conference Papers	24
Concluded PhD	1
Concluded MSc	7

Two Main Publications

F. B. Saghezchi, A. Radwan, J. Rodriguez, T. D. Dagiuklas, **Coalition Formation Game Toward Green Mobile Terminals in Heterogeneous Wireless Networks**, IEEE Wireless Communications, Vol. 20, No. 5, pp. 85 - 91, October, 2013

S. M. Mumtaz, H. Lundqvist, K. Huq, J. Rodriguez, A. Radwan, **Smart Direct-LTE Communication: An Energy Saving Perspective**, Elsevier Ad Hoc Networks, vol. 13, pp. 296-311, February, 2014

PROJECT WEBPAGE URL
http://greent.av.it.pt/

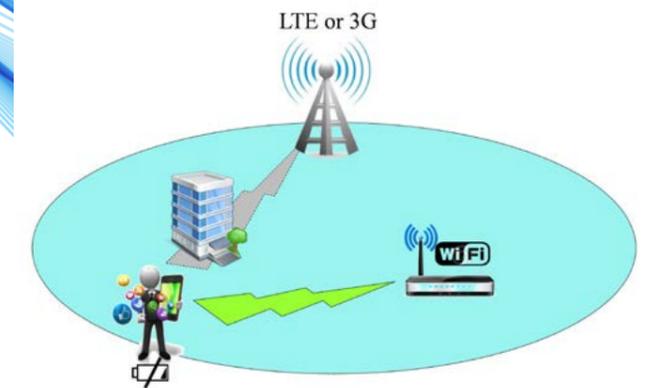**Fig. 1** Saving energy of mobile devices through short-range cooperative communications.

Fig. 2 Energy efficient handover.

GENERAL MOTIVATION AND OBJECTIVES

Today, users are enjoying a plethora of new advanced applications on their smart mobile devices, thanks to advances in the technology of mobile networks and devices. However, such advancements do not come for free; the energy consumption of mobile devices is rapidly increasing due to power hungry features, such as larger high-definition displays and more interactive applications. Unless a proactive stance is taken, the increase in energy consumption of mobile devices will continue, rapidly depleting the battery lifetime; hence confining mobile users to the nearest available power outlets; taking away the freedom of roaming promised by future mobile networking.

Green-T project investigates innovative solutions to limit the energy consumption of mobile devices targeting two main objectives: i) decreasing the whole energy consumption of mobile networks; hence contributing to the Green targets of the EU of decreasing the carbon footprints of ICT sector and ii) prolonging the battery lifetime of smart mobile devices, and hence increase its usability. Additionally, Green-T has recognized the high importance of security for 4G systems and beyond; that will constitute a multitude of players from network operators to service providers cooperating under a converged service platform; hence it investigated lightweight security approaches.

CHALLENGE

The main challenges of Green-T project include:

- EU targets decreasing the carbon footprints of FCT sector: Green-T contributed to such goal through reducing the energy consumption of the mobile terminals, whose number has drastically increased;

- Seamless user experience: with the existence of heterogeneous networking, seamless experience between networks and terminals has to be achieved. GREEN-T investigated energy efficient seamless mobility between cellular networks (3G/LTE) and short-range networks (WLAN or Wireless Sensor Networks). These new handover scenarios raised significant research challenges;

- Security and trust: The converging sectors of the industry carry a different history on security perspectives. Confidentiality is of upmost importance due to the transmission of confidential information over wired and wireless networks: GREEN-T analysed advanced energy efficient security mechanisms for cooperative schemes identifying vulnerabilities, studying and analysing different type of attacks and classifying the devices behaviour;

- Design of network architectures that are self-configured and self-managed: GREEN-T considered self-organizing short range cooperative clusters that are used to optimize the connection of multi-standard devices to heterogeneous radio access networks in order to save battery power of nodes and reduce the overall energy consumption of the network.

WORK DESCRIPTION AND ACHIEVEMENTS

Green-T has achieved energy savings through two main scenarios:

1- Power saving through exploiting short range cooperation within homogeneous networks (Fig. 1);

2- Green cognitive handover between heterogeneous RATs (Fig. 2).

The project has identified the possible energy saving opportunities using cooperative communications, smart vertical handovers, device-to-device communications, context awareness and the design of green reconfigurable transceivers.

The project also investigated other solutions, including Visual Light communication, content distribution over mobile clouds and network coding cooperative communications.

IT main contributions were:

1- Design of a tuneable miniature PIFA antenna, with desired attributes: compact size (15/8/3 mm), wide frequency range, low power consumption and reduced interference;

2- Design of smart device-to-device cooperation protocols for energy efficient communications;

The demonstrator:

3- Design and implementation of a complete LTE emulator composed of a System Level Simulator (SLS) and a Real time Link Emulator (RLTE), which represents one of the key demonstrators for the Green-T project.

The SLS simulates the behaviour of a real LTE radio access network, such as planning, scheduling and interference. The RLTE provides aspects regarding the LTE protocol stack and the information exchange between UE and eNB.

The LTE emulator is the first of its kind to allow the analysis of the Quality of Experience (QoE), since it emulates an LTE link between two devices based on the simulated networking conditions.