Heterogeneous Mobile Networks for Green Cellular Communications

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Abstract

Radio Access Network (RAN) technology is the most critical part of the capacity planning of 4G mobile networks, which are usually dimensioned for peak traffic conditions. Furthermore, the RAN infrastructure is responsible for more than 80% of the energy consumption of mobile networks.
A promising approach to increase the network capacity and simultaneously reduce the energy consumption is represented by the opportunistic utilization of third party WiFi access devices, forming a Heterogeneous Mobile Network (HMN). This approach will allow mobile operators to switch customer sessions from one access technology to another, in order to better manage their networks and accommodate more appropriately the QoS requirements of their users. The research project proposed for the PhD candidate aims at designing and developing the fundamental building blocks for managing HMNs, opportunistically deployed for reducing the energy consumption of Radio Access Networks.

The PhD student will therefore investigate innovative policies and mechanisms to foster the deployment of Heterogeneous Mobile Networks, increasing their capacity while saving large amounts of energy. Resource optimization will be performed to guarantee QoS requirements during network operation.

Scientific and technical objectives

The research activity proposed for the PhD candidate aims at anticipating the upcoming integration of radio access technologies, designing new algorithms for a wise and efficient allocation of the available network resources in order to reduce the energy consumption and the CO_2 emissions responsible for global warming effects.

In this context, the PhD candidate will:

1) investigate innovative mechanisms to foster the formation of Heterogeneous Mobile Networks;
2) propose new optimization techniques to support the long and near-term planning strategies of mobile network operators, considering the particular features of the heterogeneous scenario;
3) design new algorithms and protocols for the dynamic management of Heterogeneous Mobile Networks to simplify the reliable control of the system;
4) evaluate the proposed solutions using testbed implementations and real-life measurements.

Overview of the research activities

The **first step** of the research activity will investigate innovative policies and mechanisms to foster the deployment of Heterogeneous Mobile Networks as a means for mobile operators to increase their network capacity and save large amounts of energy, thus contributing to reduce CO_2 emissions caused by the ICT industry. The Mobile Network operator will rent the available bandwidth provided by the access devices of residential users or Wireless Internet Service Providers (WISPs), which in turn will be used to satisfy its mobile customers. More specifically, in the first step the PhD student will focus on *mechanism design* and *auction theory* to design a marketplace tailored for Heterogeneous Mobile Networks and model the economical transactions among the different

entities. Furthermore, he will analyze from a game theoretical perspective the competition among several mobile network operators on the same set of available WiFi access points, in order to evaluate the dynamics of the proposed heterogeneous system.

Due to the scarcity of available network resources, the **second step** will study and design new techniques to optimize their utilization to guarantee the QoS requirements of users sessions, in terms of throughput, transmission delay and packet loss, while minimizing the energy consumption of the overall heterogeneous network. In particular, a careful network planning represents a key element to improve its energy efficiency. To this end, within this research task, the PhD student will study and analyze *mathematical models* to support both long and near-term network planning strategies.

The **third step** will design and analyze algorithms and protocols to dynamically control the entire heterogeneous system and guarantee a seamless and reliable mobility of user sessions across different access technologies, while minimizing the overall energy consumption. In particular, the PhD student will first design and develop *prediction algorithms* to estimate essential information of the heterogeneous network for an effective control of the entire system, such as traffic load of mobile users sessions, the energy consumption of base stations, and the network capacity made available by third party devices. Then, the profiling information will be used to select the optimal resource allocation in order to provide seamless and reliable mobility across the different access technologies. Note that the key element of the mechanisms, which will be investigated within this research task, is represented by the joint optimization of the *reliability* and *energy consumption* of user communications.

Finally, a distinguishing feature of the research activity proposed for this PhD thesis is the special attention towards exploitation. To foster the utilization of our technology and solutions in the real world, this research project will set forth, in the **fourth and last step**, the following implementation strategy. First, the proposed protocols will be developed on real-life testbeds in order to evaluate their effectiveness and performance. To this end, the PhD student will follow a modular implementation of protocols and algorithms, with loadable libraries allowing flexible configuration and a middleware tailored to deployment scenarios, using open software/firmware running over off-the-shelf low-cost hardware. Then, he will implement the proposed solutions in selected case-studies that mimic actual services and functions expected for Heterogeneous Mobile Networks for Green Communications.

References

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