2009 campaign
Description of the Ph.D. Thesis

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Thesis topic (*Title*):
Study of the electromagnetic radiation in the home environment: characterization, modelling and mitigation methods

Global context of the study and state of the art
With the increasing number of services offered in the home network, such as telephony, IPTV and high throughput data transfer, digital communication systems are more and more present at home. In the wired field, data are transmitted over any type of cable, such as the electrical network (Power Line Communications), the telephone twisted pair, or coaxial cable. In the wireless field, WiFi systems operating in the 2,4 GHz and 5 GHz frequency ranges are now complemented with short range systems, such as UWB and 60 GHz systems. All these systems represent potential radiating sources and contribute to the increase of the electromagnetic noise. In addition to theses systems operated at home and installed by the householder, different non intentionally radiated waves are present in the home environment: micro-wave ovens, and outdoor transmissions such as radio broadcasting and cellular networks. A first study including the description and measurement of a number of these noise sources was performed at Orange Labs. This work shows that the addition of multiple noise sources lead to a strong increase of the radiation level at some frequencies, which may interfere with communication systems present in the home. As the market of transmission systems for the home environment is quickly evolving, this radiation issue is likely to be of greater importance in the coming years and to raise technical issues of electromagnetic compatibility, as well as societal issues linked to public health. However, there is currently no simple and accurate model accounting for the radiation level of each of these noise sources in the home environment, or for the accumulation of these sources. Experimental and analytical research thus needs to be conducted in order to obtain a better cartography of the radiation level in typical dwellings.

Objectives/ Expected results/ Scientific and technical challenges
The objective of this thesis is to develop models allowing for an accurate cartography of the electromagnetic radiation in the home environment. For this purpose, the student will first characterize and model the radiation generated by each of the different noise sources, intentional or non intentional, and then propose aggregation models for the addition of these sources in the considered frequency bands.
In a second step, and for systems with non intentional radiation, the student will study solutions to minimize the unwanted radiations. A typical application is the wired transmission over unshielded cables (electrical cables and twisted pairs), where solutions will be investigated in both analogue and digital domains.

Methodology proposed by the technical advisor
This work will be based on first results in this field, obtained during a previous Ph.D. study conducted at Orange Labs. In a first step, the student will identify and classify radiation sources in the considered frequency bands. Each radiation phenomenon will then be studied, to target a simple mathematical modelling. This study will first be theoretical, and the results will be validated by numerical simulations (RESLINE and CRIPTE software), and through experimental measurements. Then, a model of the aggregated effect of several radiation phenomena will be defined.

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In this work, the targeted frequency bands will be identified, and a priority will be given on the most problematic bands in terms of EMC constraints and of possible interference. At this stage, two bands are suggested: the lower spectral band (0-500 MHz) for wired communications will be studied in priority, and the ISM band at 2.4 GHz (WiFi systems, microwave ovens, …) will be analysed in a second step depending on the progress of the work. The studied bands may be refined depending on a first bibliographical study.
In the second part of the thesis, the work will concentrate on the lower band to define means to reduce the non intentional radiation. This work will be based on the understanding of the physical radiation phenomena in place. In particular in this band, part of the work will focus on the study of the coexistence between the VDSL2 and PLC transmission systems, which use the same frequency band.

Required skills:

- Excellent background required in the fields of electromagnetism, signal processing, and statistics
- Capacity of setting up and conducting experiments for the validation of the proposed models
- Good knowledge in digital communications
- Skilled in computer programming (electromagnetic simulation software, Matlab)
- Knowledge of one or several of the considered systems (PLC, WiFi)

The candidates will also require the following skills:

- be fluent in English, which is necessary for a research work conducted in an international context,
- be able to work within a team, with both local and distant partners, within the same company but also in a larger innovation environment,
- be autonomous while being capable of using the strengths of the recruiting structure,
- be able to present scientific results in a synthetic way, which is necessary for the research work and its promotion
- know how to confront and communicate their results, both within and outside the company,
- be able to evaluate the range of their inventions and to protect them

Global planning of the thesis

T0 to T0+3 months: Bibliographic study, priorization of the research axes
T0+3 months to T0+12 months: Experimental study of the different noise sources, characterization and modelling
T0+12 months to T0+21 months: Definition of aggregated radiation models and experimental validation
T0+21 months to T0+30 months: Definition of mitigation methods for the non intentional radiation, simulation and validation
T0+30 months to T0+36 months: Writing of the PhD report and viva.