"CONTRIBUTION TO THE ANALYSIS AND DESIGN OF HETEROGENEOUS WIRELESS NETWORKS: A COMMUNICATIONS–THEORETIC PERSPECTIVE"

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Résumé :

In the last decade, the telecommunications sector has experienced a tremendous success causing proliferation of new applications, which have increased the demand for ubiquitous heterogeneous broadband mobile wireless communications and have increased the users' and networks' load. Increasing heterogeneity in the network is considered as one of the most promising solutions for supporting the increasing data traffic demand, for reducing the power consumption of both access points and mobile terminals, and, more in general, for meeting the requirements imposed for the fifth generation of mobile networks.

Nevertheless, future deployments of heterogeneous (cellular) networks, which support macrocells, picocells, femtocells, fixed and mobile relays, cognitive radios, remote radios heads, distributed antenna–elements, *etc.* coexisting on the same spectrum in the same geographical area, lead to new technical challenges never faced before. This trend is irreversible and will have a profound impact on both the theory and practice of fifth generation mobile communications networks. To address these issues, industry and academia are working on the development of new technologies and cellular standards.

The emerging heterogeneous character of next–generation wireless communications networks constitutes the overarching *fil rouge* of the present *Habilitation à Diriger des Recherches (HDR)*. By leveraging a communications–theoretic approach, this HDR provides contribution to the theoretical understanding and design of three open research problems:

1. The amalgamation of relaying, user–cooperation and network coding for striking a better bandwidth–efficiency vs. end–to–end performance vs. energy–efficiency trade–off, by exploiting tools from communications and coding theories;

2. The proposal of tractable mathematical frameworks for characterizing the statistical properties of heterogeneous network interference and for computing the system–wide performance of multi–tier cellular networks, by exploiting tools from communications and stochastic geometry theories;

3. The design of new low–complexity and power–efficient multi–antenna physical–layer transmission techniques for striking a better spectral–efficiency vs. power–efficiency trade–off, by exploiting tools from communications and random matrix theories.

Finally, this HDR puts forth the concept of *multi–user spatially stochastic wireless networks*, which are distributed wireless networks where the interactions among the access points and the users are dynamic due to the stochastic behavior of the wireless channel, to the user mobility, to the random network topology, and to the unplanned spatial distribution of the many network elements. It is highlighted how these characteristics are common to numerous emerging application scenarios, including small–cell cellular networks, relay–aided and cognitive cellular networks, wireless sensors networks for assisted–healthcare applications, millimeter–wave communications and the smart metering network infrastructure of the smart grid. Finally, it is pointed out that the contemporary wireless communications theory has to be generalized in order to take into account the peculiarities of these emerging wireless scenarios and that a new mathematical approach leveraging tools from communications theory, stochastic geometry and point processes theory may be useful for a unified and general modeling, understanding, design and optimization of emerging wireless communications networks.