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Títol del projecte
Secure and high speed cooperative small cells for cost and energy effective 5G network - 5GNET

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BREU DESCRIPCIÓ DEL PROJECTE DE RECERCA

Small cells are envisaged as the vehicle for ubiquitous 5G services providing cost-effective high speed communications. Pivotal to the 4G revolution is the well-known femto-cell concept, which is currently the market solution for providing energy-efficient high speed internet access for indoor scenarios. Complementary to femto-cell technology, the LTE-A standard delivers the outdoor version in the form of pico-cell deployment suited for wide area coverage; however, the latter requires radio networking infrastructure and careful planning, which translates to a significant cost for mobile operators. Nevertheless, indoor femto-cell technology is here to stay with a desirable energy rating making it a winning candidate for a basic building block on which to evolve mobile networks of the future. Therefore, an intriguing question arises: what if we were to break with the current mould of typical femto applications and extend femto accessibility to the outdoor world? then, perhaps, we would stumble upon the next generation of femto-cell technology for 5G networks. This question has been partly answered by today´s small cell technology, either using fixed outdoor devices (metrocells) that provide femto-like services, or by mobile devices through tethering, but all of them provide limited , interoperability, and coverage. Hence, to fully answer this question, this proposal extends the notion of femto applications towards outdoor scenarios by employing virtual small cells. These small cells are set up on demand, and constitute a "wireless network of cooperative small cells" that have a plethora of high speed backhaul connections to the mobile network.

Based on the aforementioned design requirements, the present 5GNET proposal aims to design, implement and demonstrate an innovative protocol stack for a new line of next generation small cells that delivers ubiquitous, cost and energy-effective and high speed connectivity at any time and at any place to support 5G services in a secure fashion. 5GNET exploits promising

technologies, such as “network coding” and “node cooperation”, working in synergy with "interference management policies and small cells” to provide a new radio networking topology and terminals forming part of the 5G paradigm. In particular, the 5GNET specific objectives include:

. - Investigate and demonstrate a new networking topology to provide ubiquitous virtual small cell access (high throughput, low energy consumption) via a high speed backhaul link for outdoor scenarios by exploiting cooperation and networking coding in synergy with LTE-A networks;

- Study of coexistence between between virtual small cells and macro cells and to propose interference aware network-coded cooperation;

- Investigate advanced secure network-coding given network coded cooperative networks to secure the privacy of users and contents as well as preventing jammers and free riders;

The proposed work is broken down in 3 Tasks:

Task 1 "Network coded cooperation": This task is devoted to the analysis, the design, and the optimization of cooperative wireless networks with wireless network coding. The key objective is to study the ultimate performance (diversity) and rate (multiplexing) trade-off of these networks for practical wireless conditions, and to infer, from this study, practical design guidelines for their design and optimization. The following key issues will be investigated: i) the design of smart relaying schemes and associated decoding that exploit network coding without scarifying the end-to-end reliability(robustness to error propagation); ii) the impact of network channel state information on reliability and throughput; and iv) the design of high-rate MAC and RRM protocols that maintain a practical ratio between data and signaling.

Task 2 "Virtual small cell coexistence with cellular networks": This task is devoted to the analysis, the design, and the optimization of heterogeneous cellular networks where macro and small cells create a multi-tier architecture for better coverage and higher throughput. The main objective is to study the ultimate performance of these multi-tier networks by taking into account the random and unplanned nature of small cells interference. To this end, we will leverage a new methodological approach that is based on the application of stochastic geometry and random networks theory. The following key issues will be investigated: i) the analysis of coverage, rate, and performance of macrocell users in the presence of small cell interference under different access policies (open, closed, hybrid) and multi-antenna technologies; ii) the development of new cell associations mechanisms that take into account the inhomogeneous nature of the different cellular tiers

Task 3 "Cooperative protocols for intrusion detection": This task is devoted to the design cooperative protocols to be used between nodes in a wireless multihop network that will allow the detection of compromised nodes (intrusion detection) and react by implementing quarantine measures. An underlying cooperation protocols based on cross-layer design will developed, whilst security extensions to ensure that nodes do not check every packet and multiple nodes perform multiple checks will be considered; the cooperation protocol must be designed so that when injected/corrupted packets are detected, nodes alert their 1-hop neighbours. This will allow a distributed detection scheme that will greatly increase the detection capability of compromised nodes and significantly decrease the computation overhead in each node.

In general, our research methodology will include modelling and analysis, as well as simulation and real-life experimentation. Depending on the nature of the proposed algorithms and protocols, Markov Chains, Game Theory, Stochastic Geometry will be used. The developed algorithms will be mapped into basic building blocks and will be integrated on a well-validated custom made system level simulator of IQUADRAT. Finally, experimental studies will be conducted by using off-the-shelf shelf products.