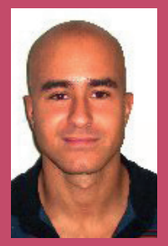

José Nuñez-Martínez is currently a Researcher in the Mobile Networks Department at CTTC in Barcelona. He received a MSc (2005) degree in Computer Science Engineering from the Technical University of Catalonia. From 2004 until September 2007, he worked as Network Engineer and Kernel Developer in the Advanced Broadband Comunication Center (CCABA) of UPC. He joined CTTC in September 2007 as a research engineer. He has participated in several national (Cicyt), European (FP7), and industrial projects (Ditech, and AVIAT). He is author and co-author of more than 20 research papers.

His current research interests include: wireless access and backhaul, Small Cells, Software-Defined Networks, Network Function Virtualization.

Abstract

The ever increasing demand for wireless data services has given a starring role to dense small cell (SC) deployments for mobile networks, as increasing frequency re-use by reducing cell size has historically been the most effective and simple way to increase capacity. Such densification entails challenges at the Transport Network Layer (TNL), which carries packets throughout the network, since hard-wired deployments of small cells prove to be cost-unfeasible and inflexible. One approach to decrease costs and augment the dynamicity at the TNL is the creation of a wireless mesh backhaul amongst SCs to carry control and data plane traffic towards/from the core network. Unfortunately, these low cost SC deployments preclude the use of current TNL routing approaches such as Multiprotocol Label Switching Traffic Profile (MPLS-TP), because these schemes are unable to provide an even network resource consumption, which in wireless environments can lead to a substantial degradation of key network performance metrics for Mobile Network Operators. To tackle such uneven consumption of network resources, this thesis presents the design, implementation, and extensive evaluation of a self-organized backpressure routing protocol explicitly designed for the wireless mesh backhaul formed amongst the wireless links of SCs. Whilst backpressure routing in theory promises throughput optimality, its implementation complexity introduces several concerns, such as scalability, large end-to-end latencies, and centralization of all the network state.

To address these issues, we present a throughput suboptimal yet scalable, decentralized, low-overhead, and low-complexity backpressure routing scheme. We formulate the routing problem for the wireless mesh backhaul from a stochastic network optimization perspective, and solve the network optimization problem using the Lyapunov-driftplus-penalty method. Rather than building routing tables, we leverage geolocation information as a key component to complement the minimization of the Lyapunov drift in a decentralized way. In fact, we observed that the combination of both components helps to mitigate backpressure limitations. We propose a self-organized controller based on locally available information and in the current packet being routed to tune such an optimization parameter under dynamic traffic demands. Thus, the goal of this heuristically built controller is to maintain the best trade-off between the Lyapunov drift and the penalty function to take into account the dynamic nature of semi-planned SC deployments. We propose low complexity heuristics to address problems that appear under different wireless mesh backhaul scenarios and conditions. The resulting decentralized scheme attains an even network resource consumption under a wide variety of SC deployments and conditions. In terms of performance comparison, our backpressure routing scheme performs better than SoA routing approaches. We conducted extensive and accurate simulations to compare the solutions proposed in this thesis against various SoA TNL routing approaches. Last but not least, we implemented and evaluated the backpressure routing strategy in a proof-of-concept. The prototype is based on an indoor wireless mesh backhaul formed amongst 12 Scs endowed with 3G and WiFi interfaces. Thus, we experimentally validated the contributions of the work conducted in this thesis under real-world conditions.

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