Radio Resource Management in Heterogeneous 5G Cellular Network

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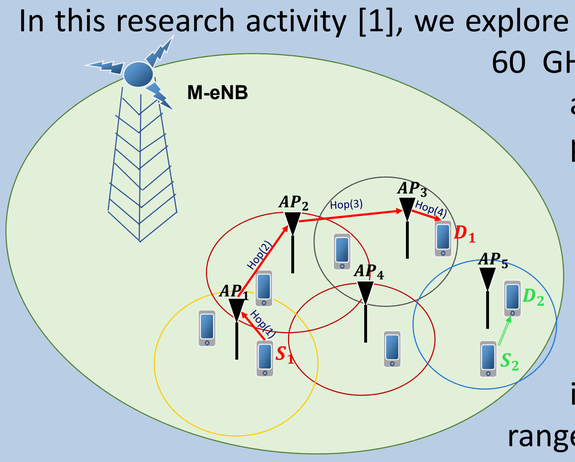
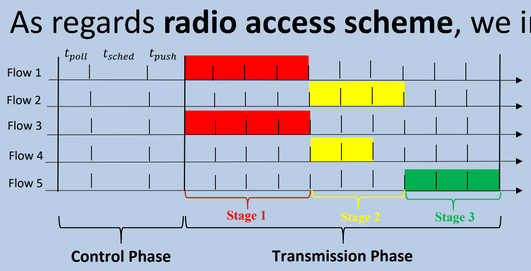
A New Centralized Access Control Scheme for D2D-Enabled mmWave Networks

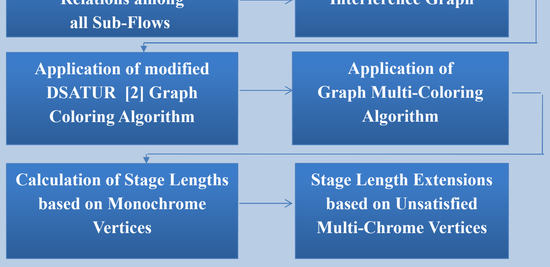
In this research activity [1], we explore the symbiosis of D2D communications, 60 GHz unlicensed band transmissions and adaptive beamforming technique. It provides improvement in the system spectral efficiency, high achievable data rate, reduced end-to-end latency, notable energy saving, and strong interference reduction. Despite these benefits, a major issue is the limited communication range, due to the high path loss. To overcome this issue, we consider a **Millimeter-Wave Mobile Broadband** (MMB) system, consisting of multiple Access Points interconnected among themselves through a wireless backhaul network. In this scenario, at the aim of enhancing transmission efficiency, we propose a centralized control scheme which jointly manages transmissions in access and backhaul networks.



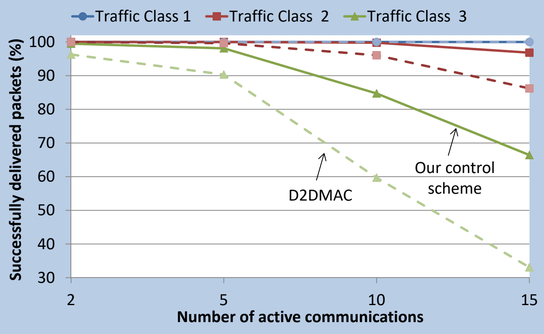
As regards **radio access scheme**, we introduce a slotted TDMA scheme with concurrent transmission support. Time is divided in frames with variable length, consisting of two phases.

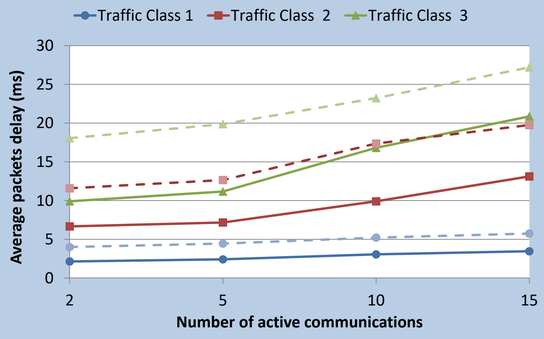


During the scheduling time of the control phase, the central controller applies an efficient **multi-criteria scheduling algorithm** using graph vertex-coloring techniques, in order to exploit concurrent transmissions, to maximize the system throughput and to minimize the end-to-end delay.



Through many **network simulations** under different configurations, we benchmark our approach against the D2DMAC [3] scheme. The comparative analysis shows that our approach outperform the considered reference scheme in terms of end-to-end delay and throughput.



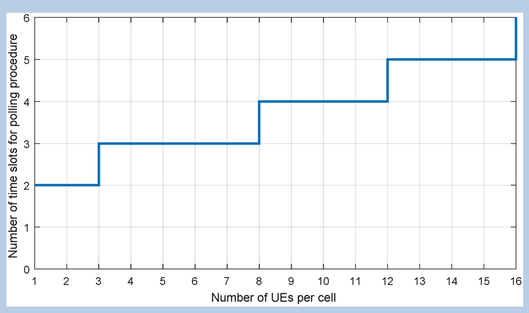


On mmWave Radio Network Planning based on a Centralized Access Control

In this research activity [4], on basis of the MMB system and the Centralized Access Control scheme described above, we focus on a radio network planning, organized in two phases: coverage planning and capacity planning.

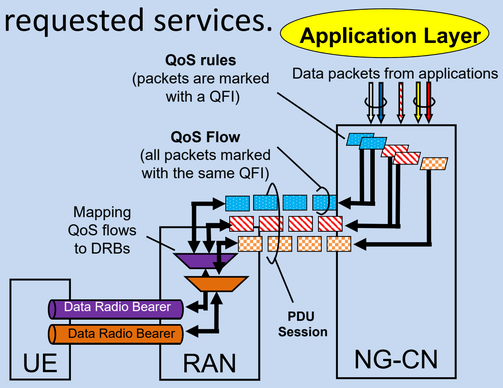
As regards the **coverage planning**, we derive coverage planning constraints, in order to ensure the functioning of the radio access scheme. Following a rigorous analytical approach which takes into account the propagation delay, the large-scale fading, and a proper guard interval, we obtain that APs must be placed in such a way as to guarantee a coverage radius of no more than **16.97m**, while two neighboring APs may be distant no more than **59.93m**.

As regards the **capacity planning**, we estimate the maximum number of users that can be managed by the system in a general network topology fulfilling the coverage constraints. Then, we analyze a Case Study in order to derive the relationship between the estimated amount of UEs per cell and the proper polling time parameter which ensures good system performance.



A New Joint Scheduling Scheme for GBR and non-GBR Services in 5G New RAN

In this research activity [5], we propose a new Radio Resource Allocation scheme for Downlink OFDMA-based 5G New Radio (5G NR), where the scheduler inside a Next Generation Node B (gNB) allocates Resource Blocks to users taking into account the Quality of Service (QoS) requirement of their requested services. To differentiate QoS attributes in the Next Generation Core Network (NG-CN), a flow-based QoS concept is adopted. As regards Radio Access Network (RAN), QoS Flows are mapped into Data Radio Bearers (DRBs), which can be Guaranteed Bit Rate (GBR) or non-GBR DRBs.

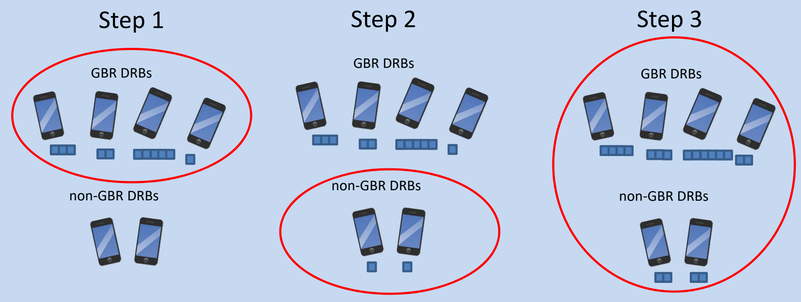


In order to efficiently allocate radio resources to DRBs, our scheduling scheme takes into account the channel conditions by means of periodic Channel Quality Indicators (CQIs) reported by UEs. We adopt the high-layer configured CQI reporting method [6], with the minimum granularity of a sub-band. Our proposed scheduler allocates Resource Blocks in the way specified in standardized Radio Allocation Types [6] by means of Resource Block Groups (RBGs).

The **goal** is to achieve a good trade-off between maximizing the system throughput and improving fairness among DRBs, while guaranteeing the minimum data rate required by GBR DRBs.

In order to improve the fairness among DRBs, the basic approach is to allocate one RBG per DRB at a time.

The overall procedure can be summarized as follows:



The choice of the proper RBGs to be allocated to each DRB depends on the strategies adopted by the scheduler. In this work, we propose two different strategies.

The first one is called **BestCQI Highest Deviation (BestCQI_HD).**

	RBG1	RBG2	RBG3
DRB1	15	10	7
DRB2	12	3	8
DRB3	10	9	5

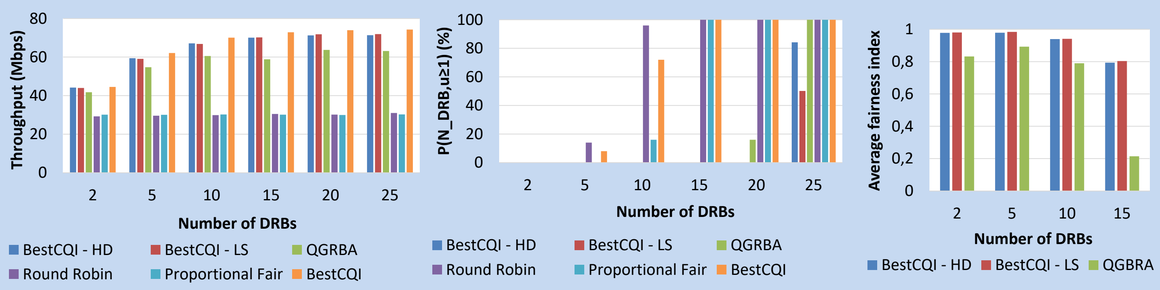
The goal is to improve the system throughput at the expense of a slight loss in terms of fairness. To achieve this goal, for each DRB the scheduler evaluates a *deviation* value, which represents the difference between its maximum and second maximum CQI value. Then, the scheduler assigns to the DRB with the highest deviation (i.e., the DRB which presents the highest deviation from its maximum reachable throughput) the RBG corresponding to its maximum CQI value.

The second strategy is called **BestCQI Lowest Second (BestCQI_LS)**.

	RBG1	RBG2	RBG3
DRB1	15	10	7
DRB2	12	3	8
DRB3	10	9	5

It aims to improve the fairness in throughput among DRBs, even at the cost of reducing the overall system throughput. The scheduler selects the DRB with the lowest second maximum value, and assigns to it the RBG corresponding to its maximum value of CQI. The adopted strategy aims to prevent a DRB from being served with a too small CQI value, therefore with a too low transmission rate.

By **simulations**, the performance of the proposed algorithms have been compared with traditional LTE schedulers and the QGRBA [7] algorithm. The results obtained show that our algorithms reach the best trade-off between throughput and fairness, while guaranteeing a larger number of GBR DRBs.



References:

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[3] Y. Niu, C. Gao, Y. Li, L. Su, D. Jin, and A. V. Vasilakos, "Exploiting device-to-device communications in joint scheduling of access and backhaul for mmWave small cells," *IEEE J. Sel. Areas Commun.*, vol. 33, no. 10, pp. 2052–2069, Oct 2015.
[4] D. Panno and S. Riolo, "On mm Wave Radio Network Planning based on a Centralized Access Control," *2018 International Conference on Selected Topics in Mobile and Wireless Networking (MoWNeT)*, Tangier, 2018, pp. 1-8.
[5] D. Panno and S. Riolo, "A New Joint Scheduling Scheme for GBR and non-GBR Services in 5G New RAN," *2018 IEEE 23rd International Workshop on Computer Aided Modeling and Design of Communication Links and Networks (CAMAD)*, Barcelona, 2018, In press.
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