ScuDo

Scuola di Dottorato ~ Doctoral School

WHAT YOU ARE,TAKES YOU FAR

XXXII Cycle

Backhaul connections from small cell mobile base stations to fixed macro base stations

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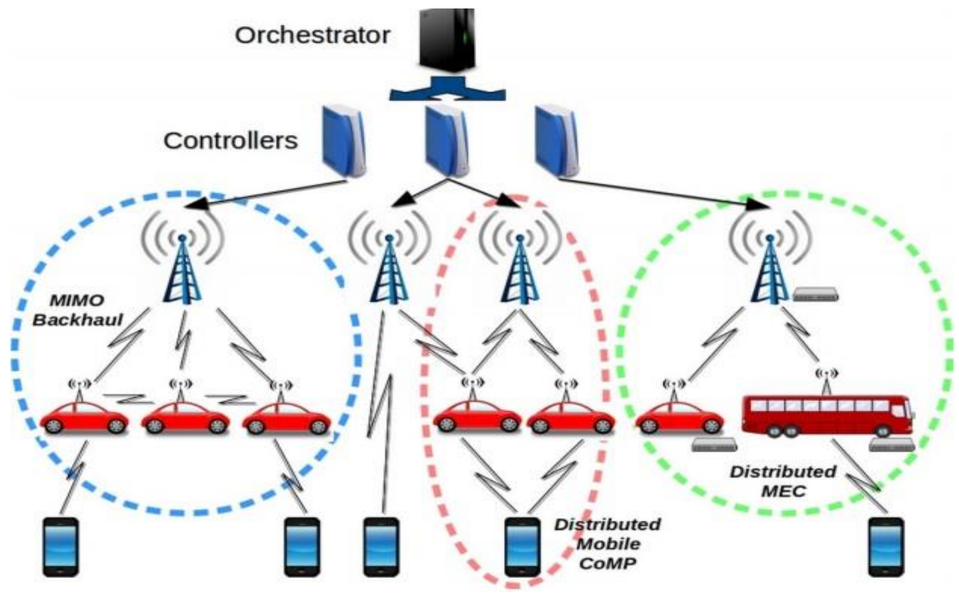
Research context and motivation



Densification of radio access networks with small cells on vehicles.

- Year one: analysis of the correlation between telecom traffic and vehicular traffic
- Year two: quantification of the improvement in the throughput from small cells on cars or macro base stations toward end users
- Year three: investigation of the impact of the backhaul connection between small cells and macro cell

Methodology

- Four alternatives for backhaul connections were considered, using either millimeter waves or standard cellular frequencies.
- We defined optimization algorithms for fairness and throughput maximization by minimizing interference by exploiting selective muting of small cells in short time intervals.
- The objective function of the optimization problem is defined as the summation of the logarithms of the end user throughputs. The optimization result is a vector that shows the probability of each on/off configurations of small cells. As a result we obtain the fraction of time in which each configuration of on/off small cells must be selected.
- The problem is computation and memory intensive, so it was necessary to run scripts in very high capacity servers and to devise heuristic approaches.
- In cases with large numbers of small cells (over 15, corresponding to 32768 states), we resorted to a heuristic that considers a reduced number of configurations (those with zero, one, two small cells active, and those with all, all minus one, all minus two).
- Below is the formalization of one of the four optimization problems:

Problem PFM :

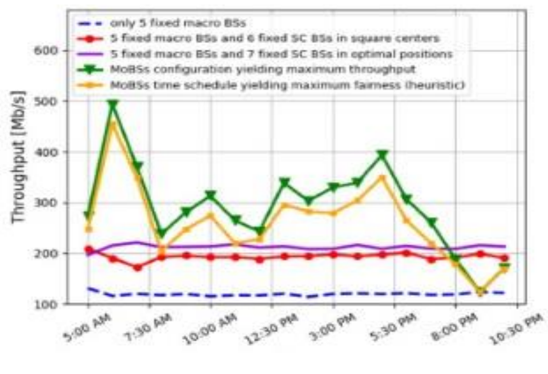
At time t, with N_t UEs in the area, select $P_B, \forall B \in \mathscr{B}$, so to:

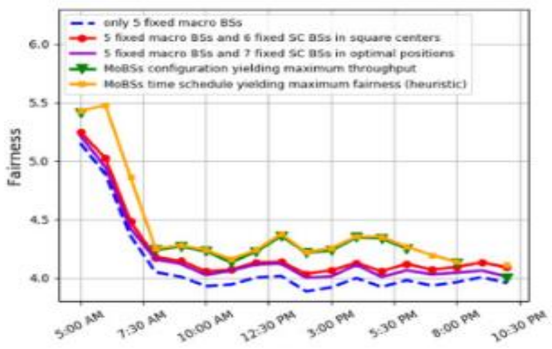
$$\text{maximize} \quad \frac{1}{N_t} \sum_i \log \left(\sum_{B \subseteq \mathscr{B}} P_B \Gamma_i^B(t) \right);$$

$$\text{subject to:} \quad \sum_{B \subseteq \mathscr{B}} P_B = 1,$$

$$P_B \in [0,1], \quad \forall B \in \mathscr{B}.$$

Novel contributions





Addressed research questions/problems

The four considered backhaul alternatives for the connection between the mobile small cell base stations and the fixed network elements (macro base stations) are the following:

1. The backhaul connection is implemented with a millimeter wave link, so as to have very large capacity for the transmission of the traffic generated by all end users connected to mobile small cell base stations, and to avoid interference with the lower frequency channels connecting either fixed macro base stations or mobile small cell base stations to end users.
2. The backhaul connection is implemented with a cellular frequency link in a band separate from the one used for end user connections. We assume the same bandwidth is available for the backhaul links and for the communications between end users and macro/small base stations.

3. The backhaul connection is implemented with a cellular frequency link in the same band used to reach end users from fixed and mobile base stations. The bandwidth is optimally divided between backhaul and end users links.

4. The backhaul connections share the only available cellular band with end users transmissions, with no a-priori allocation.

Future work

- Simulation of the dynamic environment, adding mobility to network elements (cars and end users), together with the resulting handovers.

List of attended classes

- 01RISRP – Public speaking (16/02/2017, 1 CFU)
- 01QTEIU – Data mining concepts and algorithms (01/03/2017, 4 CFU)
- 02RHPRP – Intellectual Property Rights, Technology Transfer and Hi-tech Entrep (23/03/2017, 6 CFU)
- 01LCPIU – Experimental modeling: costruzione di modelli da dati sperimentali (03/04/2017, 6 CFU)
- 01PJMKG – Etica informatica (05/05/2017, 4 CFU)
- 01QSAIU – Heuristics and metaheuristics for problem solving new trends and so (11/05/2017, 4 CFU)
- 02LWHRP – Communication (07/06/2017, 1 CFU)
- 01QORRV – Writing Scientific Papers in English (08/06/2017, 3 CFU)
- 02NDLLZ -- Lingua italiana I livello (20/09/2017)
- 01RNBRV -- Communication II (5/10/2017, 2 CFU)
- 01RONKG -- Python in the Lab (24/01/2018, 4 CFU)
- 01RZURV -- Il criterio di responsabilità nella ricerca e nell'innovazione – II (11/07/2018, 4 CFU)
- 01RELKG -- Probabilità applicata e machine learning (10/09/2018, 6 CFU)

Submitted and published works

- Abdollah Kavousi Fard, Haidar Samet, Foroogh Mohammadnia, “Evolutionary short term load forecasting based on ANN: A comparison with the most well-known algorithms”, IEEE 24th Iranian Conference on Electrical Engineering ICEE, Oct. 2016, pp. 133-137 (Published)
- Behrouz Safarinejadian, Foroogh Mohammadnia, “Distributed weighted averaging-based robust Cubature Kalman Filter for state estimation of nonlinear systems in wireless sensor networks”, IEEE 6th International Conference on Computer and Knowledge Engineering ICCKE, Mashhad, Iran, Jan. 2017, pp. 66-71 (Published)
- Ahmadreza Jenabzadeh, Behrouz Safarinejadian, Foroogh Mohammadnia, “Distributed Consensus Filter for a Class of Continuous-Time Nonlinear Stochastic Systems in Sensor Networks”, Asian Journal of Control, vol. 19, no. N, May. 2017, pp. 1284-1294 (Published)
- Foroogh Mohammadnia, Marco Fiore, Marco Ajmone Marsan, “Adaptive densification of mobile networks: Exploring correlations in vehicular and telecom traffic”, IEEE 17th Annual Mediterranean Ad Hoc Networking Workshop (Med-Hoc-Net 2018), Capri, Italy, Jul. 2018, pp. 1- 8 (Published)
- Foroogh Mohammadnia, Christian vitale, Marco Fiore, Vincenzo Mancuso, Marco Ajmone Marsan, “Mobile Small Cells for Adaptive RAN Densification: Preliminary Throughput Results”, IEEE Wireless Communications and Networking Conference, Marrakech, Morocco, Apr. 2019 (Published)
- Marco Ajmone Marsan, Foroogh Mohammadnia, Christian Vitale, Marco Fiore, Vincenzo Mancuso, ‘’ Towards mobile radio access infrastructures for mobile users’’, Ad Hoc Networks, vol. 89, no. N, June. 2019, pp. 204-217 (Published)

POLITECNICO DI TORINO

PhD program in

Electrical, Electronics and Communications Engineering