Developing the Science of Networks

Optimizing 5G Networks

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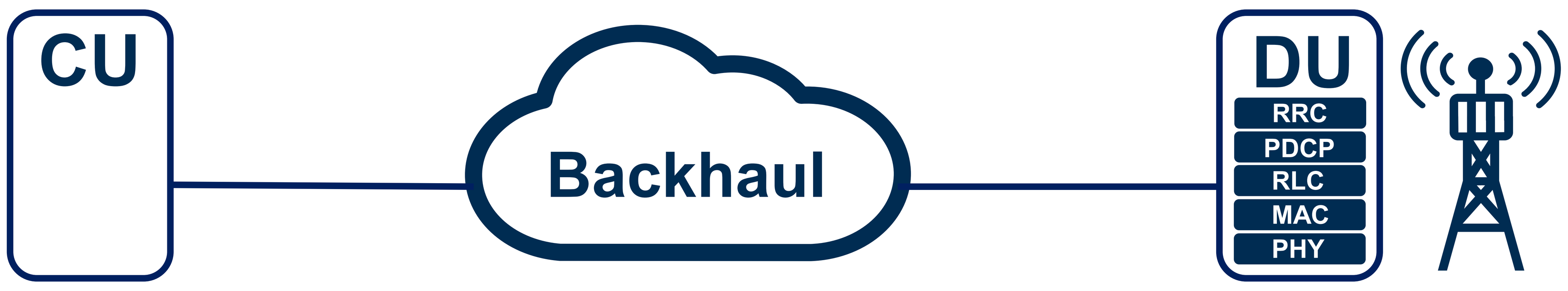
Motivation

5G is the future generation of telecommunication networks which goals are to reduce latency, increase bandwidth and enhance mobile broadband.

The transport network that feeds the Radio Access Network (RAN) can be improved to support the increased bandwidth by splitting the radio elements/functionalities that composes it. This **Base Stations (BS) Functionality Centralization** is required in 5G:

- **D-RAN:** distributed RAN (traditional), does not centralize any BS function.



- **C-RAN:** Cloud or Centralized RAN, all BS functions in a Central Unit (CU).
  - Good user performance
  - Low-cost BS (softwarized processing)
  - Stringent networks constraints

- **5G:** New BS Functional Splits required.
  - Relax C-RAN's stringent constraints
  - Retain maximum feasible degree of RAN centralization

Methodology

Network that integrates fronthaul traffic and backhaul traffic within the same links and nodes: **5G-Crosshaul network.**

Different requirements:

- **Fronthaul:** low latency and high bandwidth
- **Backhaul:** several bandwidths and less restrictive delays

Goal: optimize the placement of DUs inside XPUs (Crosshaul Processing Units), CUs and routes of traffic guaranteeing the requirements of each type.

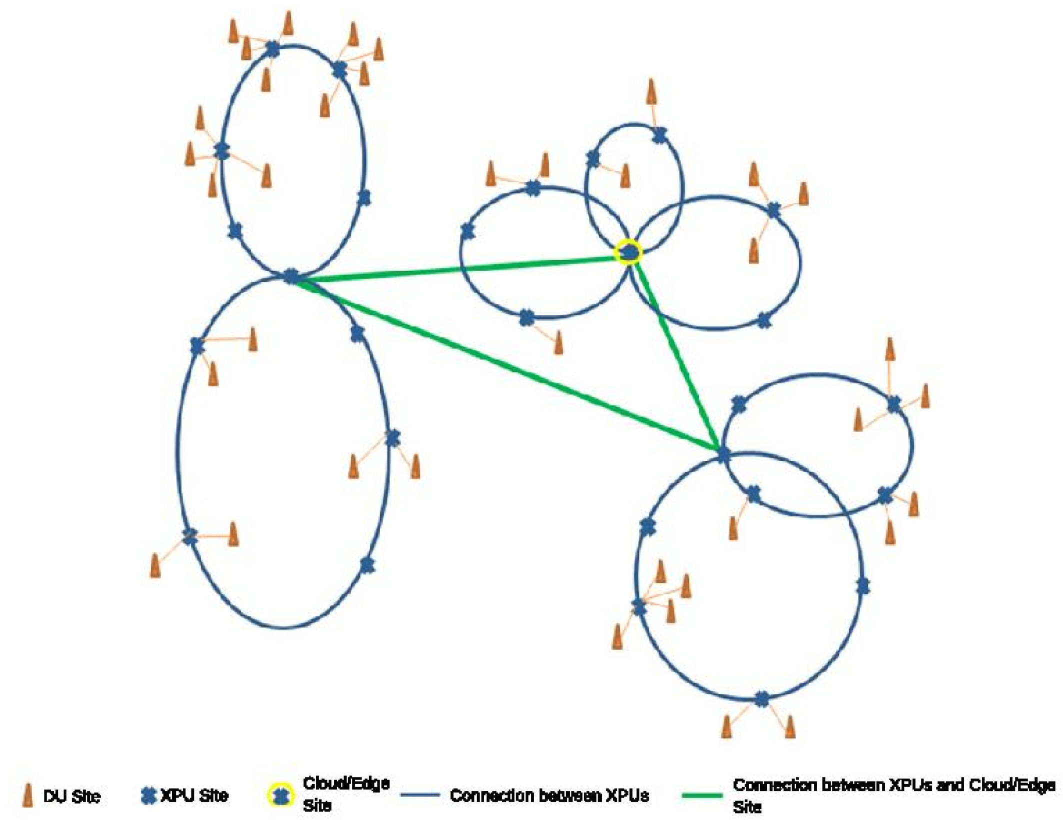
Objective: maximize the bandwidth

$$\max g \cdot \sum_l \beta_{f^l} + \sum_r XPU^r$$

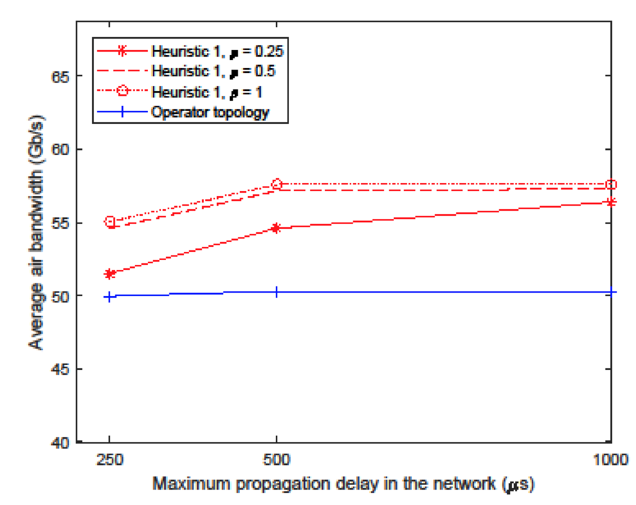
Constraints:

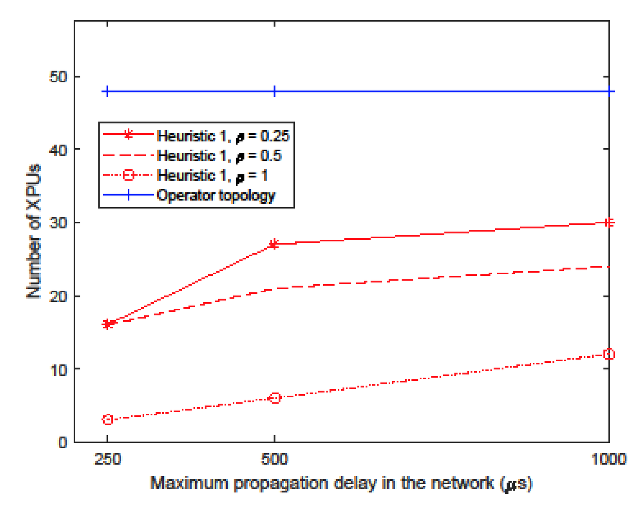
- Single path: $\sum_l x_{ij}^{f^l} \le \beta_{f^l}$, $\sum_{l,k} x_{ij}^{b_k^l} \le \beta_{b_k^l}$
- Link capacity: $\sum_{l,k} b_k^l \cdot x_{ij}^{b_k^l} + \sum_l f^l \cdot x_{ij}^{f^l} \le c_{ij}$
- Fronthaul flows to CUs: $\sum_l \beta_{f^l} = \sum_r CU_{f^l}^r$
- CUs into XPUs: $CU_{f^l}^r \le XPU^r$
- No traffic losses: $\sum_i x_{ij}^{f^l} = \sum_r x_{jr}^{f^l}$, $\sum_i x_{ij}^{b_k^l} = \sum_r x_{jr}^{b_k^l}$
- Constraints for delay and other requirements

Problem modelled as MILP → NP-hard, hard to solve big networks → heuristic algorithms proposed to solve real networks.



Results





Results for a synthetic operator network showing the gains in bandwidth and DUs using our optimal and heuristic algorithms in the deployment of the infrastructure. In the heuristics we define a maximum load in the links, ρ.

Conclusions

Development of a framework applicable to the optimal design or dynamic management of a mixed RAN and C-RAN environments, foreseen on the road to 5G networking.

Reference

N. Molner, A. de la Oliva, I. Stavrakakis, A. Azcorra, "Optimization of an integrated fronthaul/backhaul network under path and delay constraints", Ad Hoc Networks vol 83, pag. 41-54, 2019