Efficient 5G Data Frame Scheduling

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Motivation and Goal

My main motivation was my fascination with algorithms and the opportunity to optimize NP-hard problems using heuristics. My goal is to deepen my understanding of optimization and network technologies.

Literature/inspiration list

- Codeforces Problem
- Radio resource allocation in 5G wireless networks
- Deterministic scheduling of periodic datagrams for low latency in 5G and beyond

ICPC 2023 Online Challenge powered by Huawei

By ICPCNews, 5 months ago,

Hello, Codeforces!

From the ICPC 2023 World Finals, we are happy to bring you an exciting online event: **The ICPC 2023 Online Challenge powered by Huawei**, which will start on November 20, 2023 15:00 UTC (UTC+8)

In this Challenge, you will have a unique chance:

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- to **solve 1 exciting problem** prepared by Huawei
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It is an individual competition.

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Deterministic scheduling of periodic datagrams for low latency in 5G and beyond

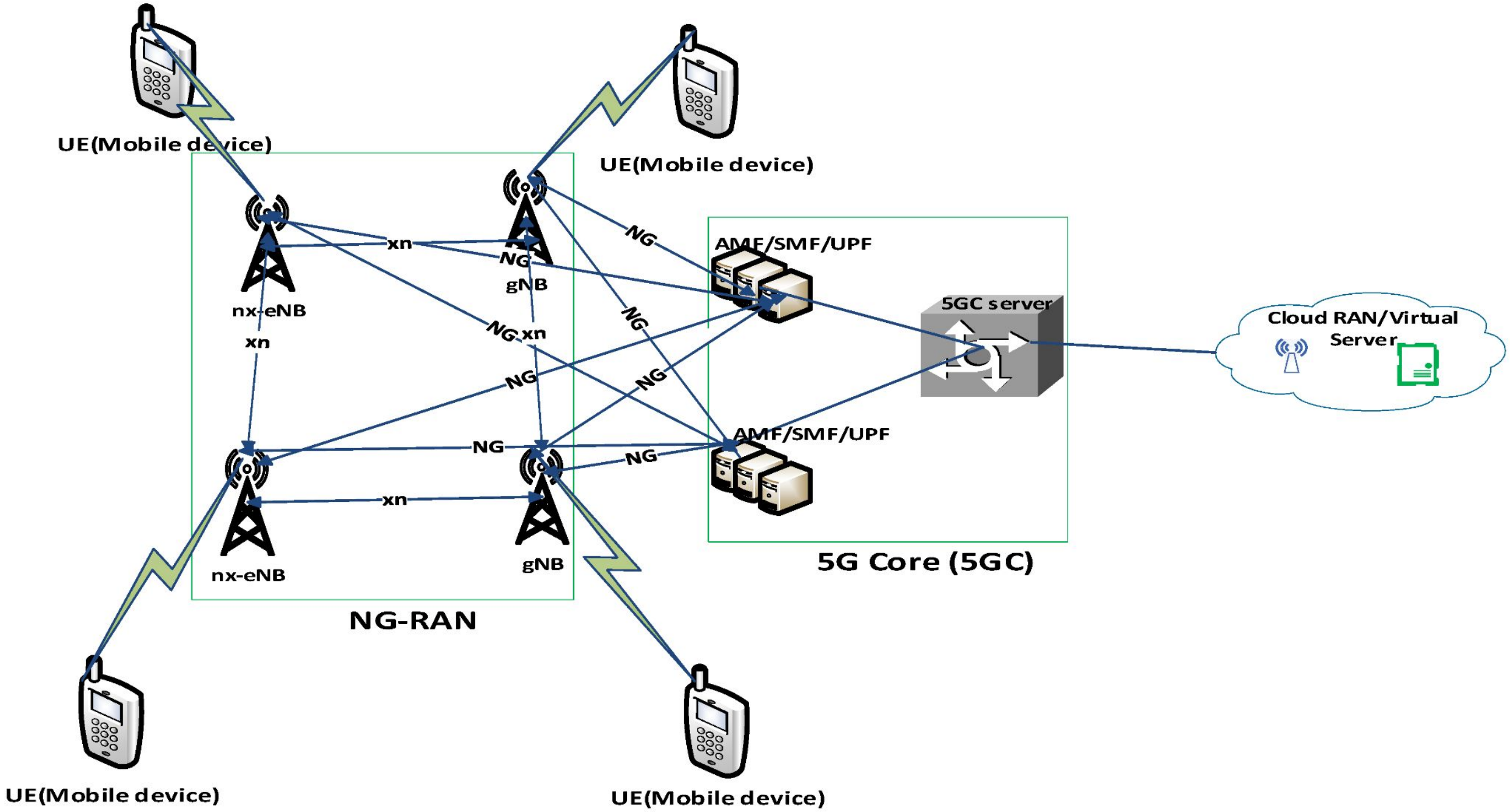
Maël Guiraud

Radio resource allocation in 5G wireless networks

Bilal Maaz

Problem Statement

This problem involves designing a scheduling algorithm to maximize the number of successfully transmitted data frames by efficiently allocating radio resources in a network environment. This includes managing transmission time intervals (TTIs), resource block groups (RBGs), and power constraints across multiple cells and users to optimize data frame delivery.



Some nice scheme

$$\mathcal{P} : \max \sum_j f_j$$

$$f_j = \begin{cases} 1, g_j \geq TBS_j \\ 0, g_j < TBS_j \end{cases}$$

$$b_{rnt}^{(k)} \in \{0, 1\}$$

$$p_{rnt}^{(k)} \geq 0, \quad \sum_r \sum_n p_{rnt}^{(k)} \leq R, \quad \sum_n p_{rnt}^{(k)} \leq 4$$

$$g_j = W \times \sum_{t=t_{0,j}}^{t_{1,j}} \sum_k \sum_r b_{rnt}^{(k)} \times \log_2\left(1 + s_{nt}^{(k)}\right).$$

$$s_{nt}^{(k)} = \left(\prod_{r, b_{rnt}^{(k)}=1} s_{rnt}^{(k)} \right)^{\frac{1}{\sum_r b_{rnt}^{(k)}}}$$

$$s_{rnt}^{(k)} = \frac{s_{0,rnt}^{(k)} \times p_{rnt}^{(k)} \times \prod_{m \neq n} e^{d_{mrn}^{(k)} \times b_{rmt}^{(k)}}}{1 + \sum_{k' \neq k, n' \neq n} s_{0,rnt}^{(k')} \times p_{rn't}^{(k')} \times e^{-d_{n'rn}^{(k')}}}$$

Some ugly and scary formulas

Input Data

- Number of Users, Cells, Resource Block Groups (RBG), Transmission Time Intervals (TTI) and Data Frames
- Initial Signal-to-Interference-plus-Noise-Ratio (SINR) for each User-Cell-RBG-TTI
- Interference Factor for each User-Cell-RBG-User
- Information for each Data Frame (userId, size and time interval)

Objective to Maximize

In this problem we want to maximize the number of data frames correctly delivered to users over the network. To achieve this we will create an algorithm that correctly distributes the power of the Resource Block Groups.

Output Data

The output is the power allocated to each User-Cell-RBG-TTI. We must also keep in mind that there are certain constant limitations on the power we can use.

Possible Approaches

- Random algorithms
- Greedy algorithms
- Heuristic algorithms
- Optimization algorithms

Expected outcomes

The expected outcomes are an advanced algorithm improving network speed and reliability, along with deeper insights into optimization in networking, setting the stage for future wireless communication innovations.

Work Done before this module

- The work environment was prepared on Github
- Some experiments have been run
- Some test cases have been created to test the efficiency of the algorithms.
- Some data analysis has been done to try to find data patterns and distributions to better understand the input data.

Work on Week 1

- Obsidian was setup in my project
- Modify the current code to respect SOLID principles
- Add more automations and scripts to make testing and development easier

Work on Week 2

- Research and analysis of all comments and external resources in the codeforces competition
- I implemented some common algorithms in the competition, obtaining good results

Work on Week 3

- Analysis of advanced ideas used by some competitors
- I implemented some of these advanced ideas although the difference was not very high
- Currently I continue developing and researching the algorithms and ideas of the top 10 competitors. On the other hand, also reading related papers about this topic

Thank you