Optimizing the QoS of the LTE network using spatio-temporal distribution-based method in the city of Lomé

Kodjo E. F. Tossou[1,2], Sid Lamrous[1], Boroze Tchamye[2], Oumaya Baala[1]

[1] UTBM, CNRS, Institut FEMTO-ST
Belfort, France
{kodjo.tossou, sid.lamrous, oumaya.baala}@utbm.fr

[2] LaRSI, Université de Lomé
Lomé, Togo
{ktossou,tboroze}@univ-lome.tg

Keywords: *QoS, optimization, mobility, Tabu search, ground characterization, spatio-temporal distribution, NP-Hard problem*

1 Introduction

The exponential increase in mobile network subscribers plunges mobile operators into a daily challenge of improving the availability and fluidity of traffic. The LTE network has been designed to provide users with a higher throughput and has thus been able to combine performance, flexibility, and the ratio between quality of service (QoS) and cost. This technology was commissioned in Togo in 2018. However, mobile network operators face some congestion issues of their network traffic at various locations depending on the time of day and the time of year. Congestion issues usually occurs during peak hours in urban or suburban areas and more rarely in rural areas. This is because the maximum capacity of the antennas is very quickly exceeded by the number of subscribers requesting its services.

In the literature, several solutions are based on meta-heuristics, big data, and performance indicators. Some solutions focus on resource allocation optimization using big data, and performance analysis [1], while others use Tabu Search approach [2] or the NSGA2 (*Non-Dominated Sorting Genetic Algorithm 2*) [3] for resource allocation in the LTE network.

In this research work, we devise an approach to optimize the resource allocation of the LTE network in the city of Lomé, Togo, which is relying on a spatio-temporal ground characterization, the distribution of the population leveraging that characterization and the use of the Tabu search algorithm to optimize the resource allocation.

2 Problem Modelling

2.1 Meshing the area of study

The study area is equally divided into 25 m x 25 m meshes. Each mesh represents the number of clients c at a time t. A mesh can be covered by several antennas, but it is attached only to the one that offers the highest Signal-plus-Interference-Noise-Ratio (*SINR*). A mesh is represented by the notation $m_i(i, x, y)$ where i is the index identifying the mesh, and x, y the geographic projected coordinates of the mesh center.

2.2 Spatio-temporal distribution

LTE network subscribers move from one mesh to another according to his profile and the time of day. On each mesh, the number of subscribers is distributed per hour using our distribution model based on the ground characterization. The total number of subscribers associated with an antenna is the sum of subscribers on all the cells associated with that antenna. The COST-231 variant of the Hata model is used to calculate the coverage on the study area, and thus, determine the association between the meshes and the antennas.

2.3 Problem objective and constraints

We are tackling a frequency allocation problem which is an NP-Hard problem [3]. In our research context, the minimum QoS we need is a sufficient signal power for a subscriber to hold a communication across the network. Thus, the objective is to minimize the number n of non-covered subscribers C for the required service on the eNB b in a scenario s. Only active subscribers are included in this number. Three decision variables are considered for the problem resolution, namely the tilt t_b the vertical orientation of the eNB b, the emitted power p_b of the eNB b and the frequency $f_{b,n}$, frequency n allocated to eNB b. However, there are constraints related to LTE technology. Three constraints are considered in the problem formulation below:

1. An eNB b has a maximum number of neighbors V_b defined according to the frequency reuse pattern,
2. An eNB b uses one and only one carrier n,
3. A mesh m is associated to 0 or 1 eNB b at most.

This results in a mono-objective function with constraints:

$$\begin{cases} min \quad n_{b,s}^{C} = \sum n_{m}^{C} & \forall b \in B,\ \forall m \in M,\ \forall s \in S \\ s.t. \quad v_b^{MIN} \leq |V_b| \leq v_b^{MAX} & \forall b \in B \\ \qquad \sum_{n \in N} f_{b,n} = 1 & \forall b \in B \\ \qquad \sum_{b \in B} u_{b,m} \leq 1 & \forall m \in M \end{cases} \tag{1}$$

3 Solving approach

The chosen frequency reuse pattern is 1x3x3 and to solve the problem, the Tabu search algorithm is used. As input data, we use the number of active subscribers on a mesh m covered by the eNB b. This number is obtained via our ground characterization-based distribution model. Subscribers are distributed by hour. Optimization is performed during hour slots where traffic peaks are observed. We generate plausible traffic dataset based on census data, an operator antenna's position, and the ground characterization in the city of lomé. The experiments are conducted using a network composed of 153 eNB. The considered frequency is 1800 Mhz, the tilt degree range [0°, 12°] and the emitted power range [39 dBm, 46 dBm]. The number of an eNB neighbors = 8 and the minimum SINR = $0,9dB$.

References

[1] P. Kiran, M. G. Jibukumar, and C. V. Premkumar, «Resource allocation optimization in LTE-A/5G networks using big data analytics», IEEE, janv. 2016, p. 254-259.

[2] R. Khdhir, K. Mnif, A. Belghith and L. Kamoun, "Tabu Approach for Adaptive Resource Allocation and Selection Carrier Aggregation in LTE-Advanced Network," 2016 IEEE (CIT), 2016, pp. 347-353

[3] W. S. A. Qatab, M. Y. Alias, and I. Ku, «Optimization of Multi-objective Resource Allocation Problem in Cognitive Radio LTE/LTE-A Femtocell Networks Using NSGA II» IEEE, nov. 2018, p. 1-6.