The Automatic Configuration of Transmit Power in LTE Networks Based on Throughput Estimation

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***Abstract*—We present an optimization method for automatic selection of downlink transmit power of LTE eNodeB based on the estimated throughput of the network. The procedures provide self optimized network functions to minimize the inter-cell interferences and maximizing the radio resource utilization. We propose a method based on the expected link throughput based on uniform client spatial distribution and compare our approach with solution based on SINR. We show simulation results that prove that the proposed method gives higher average link rate per client and higher total network throughput than optimization methods shown in the literature.**

I. Introduction

The ability to self organize a network parameters is the important element of future cellular networks, mainly because the significant complexity of these networks. A complex structure of the Future Cellular Network (containing e.g. Femto cells) imposes a new challenges a in management of the networks. With the increasing network size and complexity increases also the amount of resources that are needed to maintaining the network. Therefore well planned procedures of the Self Organising Networks (SON) might noticeably reduce the expenditure of the network operator (both OPEX and CAPEX) [1]. In most cases, the first step of the new network deployment (or during adding a new Base Station (BS) to an existing network) is to configure the transmission power in BSs. This part is important, because the mistake in the power assignment can increase interferences in network, which lead to reduce the SINR (Signal and Interference to Noise Ratio) level and it decreases the Quality of Service (and potentially may reduce income). On the other hand, this process should be done quickly, because users expect that network will works without delays and reliable. In this paper we evaluated one of the proposed solution for this problem and compared it with the new approach.

In the paper [1] authors show the importance of the Self Organizing Networks, and gave wide survey of the field. The method to solve mentioned problem is proposed in [2]. In paper [3] authors solved wider problem for assign resources in network, but their assumption was firstly to determine the demand throughput in User Equipments (UE) and in next step to find transmission power in Base Stations to face this demands. The paper [4] proposes to optimize the handover thresholds for different types of scheduler in cellular networks using cell capacity as target function. Our goal is to find the highest possible throughput achievable in particular network deployment by tuning the transmitted power. In [5] authors solved mentioned problem by the multiobjective optimization. We improve this sollution by giving a higher resolution of the SINR heatmap.

II. Model

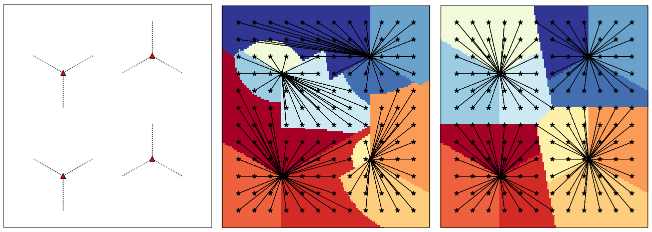
To evaluate the quality of the received signal in a UE we use the SINR formula as can be seen in (1). In proposed model to determine the Path Loss between transmitter and receiver the SUI propagation model was used, with parameters for the 'intermediate' terrain type (like in [6]). P_{tx} is the transmit power in BS connected to, PL is the Path Loss, N is the sensitivity level of the UE (in simulation N have been equal -104.5 dBm). Because antennas are sectorized, the denominator in the (1) considers only UEs which antenna direction is set towards particular UE (BS_{vis}).

$$SINR = \frac{P_{tx} - PL}{\sum_{BS_{vis}} (P_{tx} - PL) + N} \tag{1}$$

III. Methodology

We used the Simulating Annaealing algorithm as the optimization method. Implementation details were used from paper [2]. The first and the second implemented algorithms were the algorithms, which use SINR values to assess a transmission power assignment. As a cost function these algorithms calculate the SINR level for the median element of the empirical cumulative distribution function (ECDF). The first algorithm was proposed in paper [2]. To reduce amount of calculations, author of paper [2] added a restriction that to evaluate an ECDF the algorithm uses only UEs with SINR level below exact level. The second algorithm was similar, but above restriction was removed. That allows algorithm to search through the whole space solutions. The third implemented algorithm search through the whole space solution, but to evaluate the particular power assignment, the cost function calculates a sum of the throughput for all UEs, in case if BSs use the Round Robin scheduler. The last (fourth) algorithm was similar to the third one, but the cost function calculated a sum of the throughput for UEs, in case if the BS used the Fair Scheduler. Before the total throughput of the network was calculated, it has been necessary to calculate the maximum throughput of the UE. This value was calculated based on a method from the paper [6].

In our research two cases were evaluated: (i) 4 BSs deployed in a honeycomb with 144 UEs located in a grid and (ii) 12 BSs deployed in a honeycomb and 1089 UEs deployed in a grid. The deployment of the case (i) is shown in Fig.1. Each BS has three sectorized antennas with horizontal angle of 120 deg. The transmission power of each antenna was controlled separately. Due to random character of the method, the algorithm was run 30 times (all with the same devices deployment). Simulations were implemented in the Python language.



(a) Network topology with antenna sectors (b) SINR as the Cost Function (c) Throughput as the Cost Function

Fig. 1. Heatmap of the SINR around BSs for different cost functions

TABLE I. SIMULATION RESULTS

Method	Network throughput with RRS	Std. dev of throughput with RRS	Network throughput with FS	Std. dev of throughput with FS
Temesvary [2]	474.1597	95.49334	42.47614	22.35761
Temesvary [2] (mod.)	571.4828	53.12361	65.64935	27.7805
Round Robin scheduler	1032.068	0	387.8585	0
Fair Scheduler	1032.068	0	387.8585	0

IV. RESULTS

Fig.1(a) show the positions of all BSs with antenna sectors. Fig.1(b) shows the distribution of the SINR level around BSs in the case with 4 BSs. Each color shows the area where the SINR level with the corresponding antenna is the highest. The aim of the algorithm is to assign a transmission power to each BS and to connect UEs to the BS with the highest SINR level. At the area belonging to each BS all UEs (shown as stars) are connected to the BS. On Fig.1(b) areas of the SINR level connected with each BS are more chaotic than on the Fig.1(c). The difference in the number of the UEs connected to various BSs is noticeable.

Summary of the simulations with 12 BSs case is shown in Table I. Research shows that using metaheuristic method with constraints may lead to omission of better results, like in case Temesvary. The second row (Temesvary without restrictions) has slightly better results in a throughput. In the methods with a cost functions based on SINR values all simulated repetitions gave different results. Two next rows show the results of cases with the cost function evaluating the throughput. Results of these two cases are equal. Probably it is the effect of the grid deployment of UEs. Nevertheless the outcome of algorithms with throughput cost functions is significantly higher. Because in all replications algorithms gave this same results, we consider the outcome of the algorithm as a quasi-optimal result.

The another important metric for transmission power assignment is the SINR value achieved in all UEs. Fig.2 shows the empirical cumulative distribution function of SINR values in the 12 BSs case. The Temesvary method and its modification achieved similar results. The higher results are achieved by methods which maximize a throughput for UEs.

V. CONCLUSION

Presented results show that the SINR-based assignment of the transmission powers to BSs in cellular networks leads to sub-optimal solutions and large variance of achieved results. If the estimated network throughput is used to asses a possible solution, it is possible to achieve higher total network

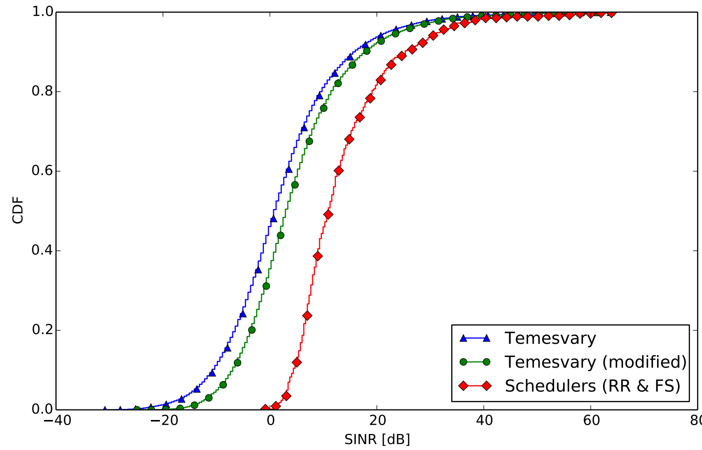
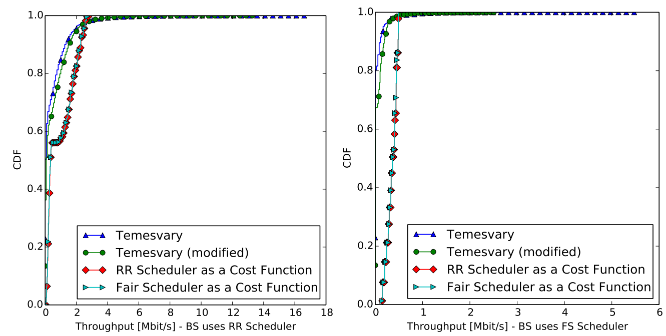


Fig. 2. Comparison of the SINR empirical cumulative distribution function for all UEs



(a) ECDF if BSs used RRS (b) ECDF if BSs used FS

Fig. 3. Comparison of the SINR empirical cumulative distribution function for all UEs

throughput and higher average SINR. The results show that the proposed methods is more likely to provide a quasi-optimal configuration.

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