

A Novel Algorithm for Optimization of Mobile Network Performance with Self-Organized Network

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Abstract—Self-organizing Networks is a key driver for improving automated management in 4G and 5G networks. It reduces installation and management cost through simplifying operation task by self-configuration, optimization and healing of the network. In this context, load balancing, capacity optimization and mobility robustness optimization are examples of SON tools to improve network performance. As those tools achieve their function by adjusting the same parameters, a conflict is induced with these performance metrics. In this paper, we address the conflict resolution problem resulted from automated management of SON for different performance metrics. In addition we provide a novel solution for concurrent optimization of capacity and robustness while maintaining load imbalance between cells to its minimum value. The proposed solution is compared against two benchmark schemes to further illustrate the improvement of network performance with SON proposed algorithm in terms of throughput, robustness, and load distribution.

Index Terms—Self-Organized network, MRO, MLB

I. INTRODUCTION

In the past few years, mobile data demand has risen exponentially [1]. This trend is expected to continue in the next several years [2]. In order to meet the exponentially growing demand of mobile data, the number of eNodeBs (eNBs) and TOTEX (Total EXpenditures), i.e. sum of CAPEX (Capital Expenditures) and OPEX (Operational Expenditures), in next generation broadband cellular networks are also growing exponentially. To reduce the TOTEX for next generation cellular networks, e.g. Long-Term Evolution (LTE), self-organization, i.e. auto-tuning of network functionalities, has been proposed by 3rd Generation Partnership Project (3GPP) [3].

Network operators want to run their network according to pre-defined target values so that performance is optimized towards their specific technology objectives. These target values are often defined by Key Performance Indicators (KPIs). With the more and more emerging Self-organizing Network (SON) paradigm the improvement of KPIs can be done by various SON function that are running (in a stand-alone manner or in parallel with other SON functions) in the network [1].

With SON functions it is possible to optimize, configure or to heal the network by monitoring the network status and changing network configuration parameters accordingly

The key goal of 3GPP standardization has been the ability to support SON features was introduced to automatically configure and optimize a wireless network by reducing manual involvement [3]. Self-optimization aims at improving network performance by adaptively adjusting system parameters based on network status.

Among self-optimization case studies Mobile Load Balancing (MLB) is part of the self-organizing network concept, which was introduced in LTE. By deploying MLB in the mobile network, gains in terms of higher network performance and an increasing number of satisfied users are the optimization goal. This is supposed to be achieved by decreasing over loaded cells in the network. Usually the MLB function in SON monitors the load of the cell and begins to distribute the traffic of highly loaded cells among less loaded neighboring cells in the network.

Beside Mobility Load Balancing, Mobility Robustness Optimization (MRO) as one of the use cases in the self-organization networks has been investigated to decrease one of link performance metrics which is radio link failures (RLFs) and unnecessary handovers due to improper handover parameter settings.

The MRO is considered in SON in order to dynamically improve the network performance in terms of Handover (HO) which provide improved end-user experience as well as increased network capacity. This is performed by automatically adapting cell parameters to adjust handover boundaries based on feedback of performance indicators.

Among self-optimization case studies, Mobility Robustness Optimization (MRO) aims to improve user mobility performance by optimizing handover-related parameters.

If the parameters are not appropriately set, when users in service move from one cell to another (referred to as handover), radio link failures (RLFs) and ping-pong can occur. As RLF causes user equipment (UE) to physically lose the radio connection, additional retransmissions or reconnections are required which interrupts user service and wastes network resources

MRO, also known as handover (HO) parameter optimization, optimizes the HO performance of the network by selecting the optimum HO point [3]. The target of the optimization is to reduce HO related failures and ping-pong HOs. On the other hand, MLB reduces the congestion in traffic hotspots by forcing HOs of suitable users from overloaded hotspot cells to their less loaded neighbor cells [4]. MLB is achieved by advancing HOs for overloaded cells and delaying HOs for their less loaded neighbor cells simultaneously. This change in HO point to achieve Load Balancing (LB) can lead to worse SINR (Signal-to-Interference plus Noise Ratio) conditions for the users. Resultantly, HO performance of the network can degrade, in turn triggering MRO to optimize HO performance. Hence, MLB can trigger MRO to bring the HO point to optimum settings and MRO can in turn trigger MLB to bring the HO point to settings where congestion in traffic hotspots is reduced. As a consequence, MLB and MRO working in parallel can lead to oscillations [5]. In order to avoid these oscillations, we need to have some kind of conflict resolution mechanism or coordination between MLB and MRO.

3rd Generation Partnership Project (3GPP), coverage and capacity optimization (CCO) function and load balancing (LB) function are of top-most importance. Given their relative importance compared to other SON functions, CCO and LB have received considerable attention from the research community [4]. However, the concurrent operation of CCO and LB in real networks creates conflicts due to their dependency on the same optimization parameters including Tx powers, antenna tilts, and cell individual offsets (CIOs) [6]. Aside from the explicit parametric conflicts between CCO and LB SON functions, the dependence of cell load on SINR also creates an implicit conflict between them. Many users are associated with loaded cell compared to non-loaded cells due to its better SINR. This translates into higher resource occupancy at loaded cell, thus causing more interference to cochannel cells. Higher interference to neighboring cells, in turn, degrades SINR of users associated with them. In addition and more important, enforcing users at loaded cells to offload to non-loaded cells with less SINR experience to make load balance between the two cells, may lead to less overall network capacity.

The remainder of this paper is organized as follows. Section II briefly reviews the related works. The system model is presented in section III and the problem statement and solution is introduced in section IV. Numerical analysis and results are provided in section V. Finally, the paper is concluded in section VI.

II. RELATED WORKS

In commercial networks, to-date CIO values are set using adhoc methods. Some recent academic studies on LB that do consider CIO as a parameter of interest [6]–[9], provide heuristic solutions for finding CIO values to

balance cell loads but fall short of assessing the impact of CIO on user QoE. These studies effectively verify the conclusion drawn from the above example that heuristic or ad-hoc settings of CIO can create more problems than they solve. Additionally, an effective solution towards LB or CCO in emerging HetNets cannot simply focus on one or two parameters out of CIO, antenna tilt, and transmit powers, but must take into account the interplay among all three parameters. There exists some recent studies on CCO [10]–[12] that focus purely on SINR optimization with one or two of the aforementioned parameters.

Compared to CCO, LB has been studied more extensively, e.g., see the survey on LB and the references therein in [13]. However, most of these studies on LB consider hard parameters only i.e., tilt, and/or transmit power for optimization and do not include CIO (see Fig. 5, in [13]). Tilt and transmit power based LB may work for macro cell only networks, but these two parameters alone cannot offset the imbalance of cell load between macro and small cells in HetNets. Only a handful of studies consider CIO as an optimization parameter for LB [14], [15], alone or with at most one other parameter.

While CCO [16]–[18] and LB [14], [15], problems have been addressed individually and extensively in literature, the co-design of CCO and LB, the only practically viable way to implement both CCO and LB in a HetNet concurrently, has received limited attention. Co-design of other SON functions such as Mobility Robustness Optimization and Mobility Load Balancing [19], and LB and Handover Optimization [20], [21] has been studied from various perspectives. However, co-design of CCO and LB is particularly challenging because of their parametric overlap as explained in [22] as well as objective conflict between the two SON functions as expatiated in [23]. As a result, most LB solutions presented in literature often balance load at the cost of CCO, and vice versa. An effective solution has to be a judicious combination of both CCO and LB. In [24], the study proposes joint optimization of CCO and LB by minimizing the log sum of cell loads in the network while maintaining minimum coverage threshold via a constraint. A heuristic algorithm is used to first optimize antenna tilts for load balancing. The cell partitions thus obtained are further refined using CIOs since the authors argue that accurate cell coverage mapping with antenna tilts is not possible in real world scenarios. The most relevant study to our work is presented in [5], which performs concurrent optimization for CCO and LB. The solution makes use of the three parameters of interest i.e., transmit powers, antenna tilts and CIOs. As proposed in [5] CCO-LB solution leverages transmit powers, antenna tilts and CIOs within one formulation.

Our approach is fundamentally different than that in [5] in the sense that instead of focusing on load minimization, our objective function is focused on throughput maximization, but embeds LB into the optimization problem through a built-in load fairness measure among cells as well as through introduction of a novel load

aware cell association mechanism. A novel scheme is proposed in [25] to maximize utility function of the integrated coverage and capacity. It begins with the analysis on the throughput proportional fairness algorithm and then proposes the novel Coverage and Capacity Proportional Fairness allocation algorithm along with a proof of the algorithms convergence.

III. SYSTEM MODEL

In this Section, we describe the system model employed in the formulation of the joint CCO-LB SON function and the underlying assumptions to validate load balancing between cells with cell throughput improvement while maintaining MRO in accepted level. The proposed model is a network with randomly deployed eNB. We focus on the downlink transmissions.

In different with most research in this area which based on ideal hexagonal grid model, all eNBs are distributed as homogeneous PPP and denoted as φ for macro cell whereas the eNB densities are λ_i . The performance evaluation based on the ideal hexagonal grid model is no longer applicable and even intractable. PPP is the most acceptable model to represent the distribution of macrocells. This is because it captures the variability of eNBs' locations [26]. The association region of the macrocell is the region of which all users of the eNB are connected to. The randomness behavior of this region can be formulated as a random tessellation [27], [28]. This tessellation is a general case of the circular Dirichlet tessellation (multiplicatively weighted Voronoi). The PDF of Dirichlet tessellation is obtained by gamma function. The widely accepted Poisson point process (PPP) is used to model the UE location as well in order to take the spatial randomness into consideration. A homogeneous PPP with density λ_u is used to model UE distribution at the cell area.

An Orthogonal Frequency Division Multiple Access (OFDMA) based system with resources divided into physical resource blocks (PRBs) of fixed bandwidth, is assumed. For conciseness, the downlink direction is chosen for the analysis as this is where most imbalances in coverage between macro cells occur.

The most suitable formulation for our problem is user throughput optimization problem with condition of maintaining load balance and MRO between cells in optimal level. This formulation provides incorporation of QoE in optimization problem.

To achieve this goal, we build a SINR model at first. This can be formulated by calculating the data rate of resource block (RB) assigned for user u using Shannon theory:

$$\tau_u = \omega_R^u \log_2(1 + \chi_u^i) \quad (1)$$

where χ_u^i is the downlink SINR for user u at cell i and ω_R^u is bandwidth per PRB. Then the cell throughput can be obtained:

$$\tau_i = \sum_{u=1}^{n_i} \omega_R^u \log_2(1 + \chi_u^i) \quad (2)$$

where n_i : represent the number of active users associated to cell i .

The user receives reference signal from the surrounding eNBs and make association with eNB providing the maximum reference signal.

For user u who is associated with macro cell i , the downlink SINR χ_{uR}^i of received reference signal can be expressed as the ratio of RSRP measured by this user from serving cell i to the sum of RSRP measured by the same user from all surrounding interfering cells $j \notin \varphi, j \neq i$ and the noise power N :

$$\chi_{uR}^i = \frac{P_t^i h_u^i d_{iu}^{-\alpha}}{N + \sum_{j \in \varphi \neq i} P_t^j h_u^j d_{ju}^{-\alpha}} \quad (3)$$

where P_t^i and P_t^j are the transmit powers of serving cell i and interfering cell j , α is the path loss exponent, d_{iu} and d_{ju} represent distance of user u from cell i , and α is the path loss exponent.

The numerator in (3) is obtained from the standard exponential path loss model while h_u^i and h_u^j can be modeled as random variables with either Gaussian or log-normal distribution varying over both space and time to represent the Rayleigh fading channel for eNB i and user u where h_u^j & $h_u^i \sim \exp(1)$.

The expression 3 is only useful when estimating the quality of reference signals which are always being transmitted by all the cells.

The former SINR depends on interference from control (not traffic) signal which is generated from nearby cells, so it has no impact on the provided data rate with this RB. The effective SINR is SINR which is generated by using the same RB at nearby cells. So it depends on utilization. As this value depends on the traffic at each TTI, so this SINR is function of time.

We follow [5] to obtain an estimated SINR independent of time using low complexity substitution for average downlink interference from cell j with ratio of occupied RB (cell load).

The value of χ_u^i describes the real signal to interference ratio generated due to cell traffic not due to cell control signal.

The expression for SINR estimated for user u in cell i can then be given as:

$$\chi_u^i = \frac{P_t^i h_u^i d_{iu}^{-\alpha}}{N + \sum_{j \in \varphi \neq i} \eta_j P_t^j h_u^j d_{ju}^{-\alpha}} \quad (4)$$

where η_j is the cell load of cell j . By substituting χ_u^i from equation (4) to equation (2), it can be concluded that cell throughput τ_i is a function of cell load of adjacent cells $\tau_i(\eta_j)$.

When cell throughput is a function of cell load is a good representative that when we decrease cell load, cell throughput is improved as well.

In the following, we will calculate the cell load η_j as an important factor to get SINR.

- Cell load calculation η_j

In order to provide users' services, the scheduler assigns some RBs for each user. Let D_U is the minimum data rate for user u to prove his guaranteed level of QoS. Then k_U^e is number of RBs required for user u to get his service which is given as:

$$k_U^e = \frac{D_U}{\tau_U} \quad (5)$$

D_U should achieve the desired data rate for this user according to his QoS level. If there is a congestion (required RBs for each user is less than available RBs) fewer RBs are assigned for this user and the achievable data rate for this user at congestion is D_u^c then

$$k_U^c = \frac{D_U^c}{\tau_U} = \frac{D_U^c}{\omega_R^U \log_2(1 + \chi_u^i)} \quad (6)$$

Then the cell load:

$$\eta_i = \frac{\sum_{U \in i} k_U^c}{W} = \frac{1}{W} \sum_{U \in i} \frac{D_U^c}{\omega_R^U \log_2(1 + \chi_u^i)} \quad (7)$$

where W is total numbers of RB at each TTI for cell i .

The estimated cell load is obtained by modifying (7) as:

$$\eta_i^e = \frac{1}{W} \sum_{U \in i} \frac{D_U}{\log_2(1 + \chi_u^i)} \quad (8)$$

Received Power:

The coverage probability can be calculated using the RSRP of all surrounding cells. Each user is continuously monitoring the RSRP signals received from nearby cells.

Cell Individual Offset:

CIO is a combination of multiple cell association parameters introduced by the 3GPP which includes cell offsets, cell hysteresis and event related offsets. This parameters are used to decide user association to specific cell. CIO information is announced by each cell and decoded by the users as part of standard operation.

In order to achieve load balance among nearby cells, the handover between network cells is controlled. The handover is tied by specific handover condition which when exceeds certain limits, the handover event is triggered. Load balance is controlled whether by

- Relaxation the handover condition in order to make advance handover from overloaded cell to its neighbor cell or
- Tightening the handover conditions to make a postponed handover from neighbor cell to the overloaded cell.

The MLB chooses adjusting one of the handover parameters which is the cell individual offset (CIO) to achieve its optimization objective.

User's association:

User association in state of art is based on received P_{ru} at the user position. Pure received power can be led to load in balance and degradation in network throughput.

In order to achieve load balance between cells, a biasing factor "CIO" is added to the received power P_r in order to enforce users to hand over from cell to another to prove load balancing between cells.

CIO value should be tuned well as it may lead to bad mobility robustness or bad network throughput.

User association in some of literature is based on SNIR. This value of SINR is calculated from received RSRP from all nearby cells, so it does not reflect the actual cell load on a given RB, hence it has no impact on cell throughput.

In our model, we modify CIO in order to reflect the actual cell load. So we can capture more practical value of SINR.

- 1- In addition, to overcome bad mobility robustness, we assign a maximum and minimum value of CIO that should not exceed. These values are considered boundary of CIO.
- 2- If we have two cells i & j , let CIO_{ij} is a biasing factor from i to j and CIO_{ji} is a biasing factor from j to i .
- 3- If $\eta_i > \eta_j$ then:
 - $CIO_{ji} > CIO_{ji \text{ late}}$.
 - $CIO_{ij} < CIO_{ij \text{ early}}$.

where $CIO_{ji \text{ late}}$ is the minimum value of CIO_{ji} that cell i announces for user of cell j who is handed over to cell i if the power reduces it, failure handover will be resulted. Whereas $CIO_{ij \text{ early}}$ is the maximum value of CIO_{ij} that cell j announces for user i who handed over to cell j if CIO_{ij} exceeds this value, the cell j power is too small to be detected and decoded and so failure handover will be resulted. By considering this boundary, bad mobility robustness is guaranteed.

The value of CIO_{ij} should depends on the difference in load between the two cells:

$$\Delta_{ij} = (CIO_{ij \text{ early}} - P_r) (1 - \eta_j^e / \eta_i^e) \quad (9)$$

$$P_r' = P_r + \Delta_{ij} \quad (10)$$

The taken cell load in last equation should be "estimated cell load" η^e in ordered to reflect the total request in the cell.

P_r' can achieve load balanced between two cells but it may not achieve maximum throughput:

Our goal is to maximize throughput in the network while maintaining load imbalance between cells to its minimum value.

Problem statement

In order to solve this optimization problem concurrently, it should be subdivided into small parts. The proposed algorithm divides the SON sequence in three majors' stages: pairing, ranking and checking. In the following we will explain these stages in details:

Pairing stage: The SON works overall the network, but it mainly affects between each pair of cells that user is handed over between them. So we will divided the network as pairs and start to maximize the throughput between each pair which in turn maximize the overall network throughput. We will call this step with “pairing”. The pairing is initiated by the most loaded cell which starts to make pairing negotiation with light nearby cells. The cell load is checked periodically and if it exceeds predefined value, the cell starts negotiation. In the pairing negotiation, the negotiated pair is divided into master and slave. The loaded cell should be the master. The loaded cell starts the negotiation by reclaiming that it is the master and other side is the slave. If it detects that the paired cell is more loaded the state is inversed. Each cell may be master in a pair and slave in another pair. This pairing negotiation is performed with all nearby cells. The master cell checks the difference between loads at paired cell and if it is smaller than predefined value, the negotiation is terminated immediately. After negotiation, the loaded cell could know the load of nearby cells. The loaded cell then reordering nearby cells from least loaded to higher load (or in another words the difference in cell load between paired cells $\Delta\eta = \eta_i - \eta_j$). Then the loaded cell starts pairing with lightest cell.

Ranking stage: The ranking stage is subdivided into two steps: the first step is classifying users into SON users and non-SON users, and the second step is ranking process.

Not all cell users should participate in SON algorithm. For example users with good channel condition who obtain RB with high data rate, it is not suitable from throughput perspective to hand over those users to far cell. In addition, those users reside near to the serving eNB and receive signal from nearby cells that is not large enough to make successful handover. So in order not to overload SON algorithms with useless operations, and simplify SON processing, those users should be excluded from SON operation. So in the proposed model, we will classify the cell users to cell edge and cell core users.

If the received power from nearby cell P_r is smaller than $CIO_{ij \text{ early}}$, those users are not able to successfully hand to nearby cells (practically they resides near eNB and so are called cell core users). From SON perspective they are called non-SON users and consequently are not considered in SON algorithm.

On the other hand, if P_r is larger than $CIO_{ij \text{ early}}$ those users are located at the cell edge and are called SON users and are considered in SON algorithm.

So In the proposed SON model, only SON users will be considered in the ranking stage between paired cells.

Each cell will schedule core users according to the chosen schedule algorithms. The reminder resources are assigned to SON users. The SON users includes cell users who may roam to nearby cell of the pair and nearby cell users who may roam to the cell. Let the reminder

resources which will be allocated to SON users be $W_e = W - W_c$, where W_c is the allocated resources for core users.

Note: Practically, eNB reserves some resources for handover users in order to reduce handover failure due to resources availability. So W_e should be modified to include these resources, $W_e = (W - W_c) + W_h$, where W_h is the reserved resources for handover users.

After cell users are classified into SON and non-SON users, the SON users are proceeding to ranking process. In this process, from throughput perspective, the users are ranked to determine which user should handover first. This is done by assigning priority for each user. This priority should be determined according to factors that affect in total throughput of the paired cells. In the proposed SON algorithm, we use SINR of the user calculated with nominated paired cell χ_u^j and the number of RBs allocated for SON users W_e as an essential factors to rank users which can be calculated according to the following equation.

$$(\chi_u^j)^\beta \times (W_e)^{(1-\beta)} \quad (11)$$

$\beta \in [0, 1]$ is a weighting factor introduced to allow trading between the impact of SINR and required RBs for user. After that the SON users are reordered according to each user’s rank. The number of RBs required for user u to get his service.

Remark 1: actually three parameters are considered in the ranking process. This due to ranking is performed between paired cells which are reordered according the difference between loads of the pair’s cell. So the difference in load is already considered in users’ ranking.

Remark 2: practically β is taken larger than 0.5 in order to avoid making association with far cells instead of nearby cell even if the far cell has lighter load.

Checking stage: Starting from the highest priority user and gradually step down to the lower ranked users, the overall throughput is calculated and the chosen users are selected to be roamed to appropriate cell.

To formalize the optimization problem according to the proposed algorithm, let assume U_{ei} & U_{ej} are number of cell edge users at cell x where $x = (i, j)$, and i & j are the paired cells:

$$Max_{CIO} \left(\prod_c \left(\prod_{U_{x=(i,j)}} \omega_u^c \log_2(1 + \chi_{u_e}^x) \right)^{\frac{1}{|U_{ex}|}} \right)^{1/2} \quad (12)$$

$$\text{While } \min |\eta_i - \eta_j|$$

$$CIO_{ji} > CIO_{ij \text{ late}}, \text{ and}$$

$$CIO_{ij} < CIO_{ij \text{ early}}.$$

where $\chi_{u_e}^x$ is SINR for cell edge user u at cell $x = (i, j)$. Our proposed algorithm is based on degradation change in CIO value and handover users gradually.

To measure the load balancing degree of the entire network, a load balance index is defined as follows:

$$\sigma(t) = \sum_{i \in N} (\eta_i(t) - \bar{\eta}(t))^2 \quad (13)$$

where $\bar{\eta}(t)$ is the average of the cell load of the entire network at time slot t .

$$\bar{\eta}(t) = \sum_{i \in N} \frac{\eta_i(t)}{N} \quad (14)$$

IV. NUMERICAL ANALYSIS & RESULTS

In this section, the proposed algorithm is evaluated to measure the performance of SON network. We built an environment for system testing and evaluation. In this environment, the X- and Y- coordinates of macro cell is generated using uniformly distributed random variables and the coverage area of each macro cell is based on voronoi Dirichlet tessellation. The X- and Y- coordinates of users is generated using uniformly distributed random variables as well. In order to prepare a suitable SON environment, non-homogenous user distribution is adopted between macro cells, where some cells have high user's densities (loaded cells) while the others have low user's densities (light load cells). Figure illustrates the generated network which has been used in the system evaluation.

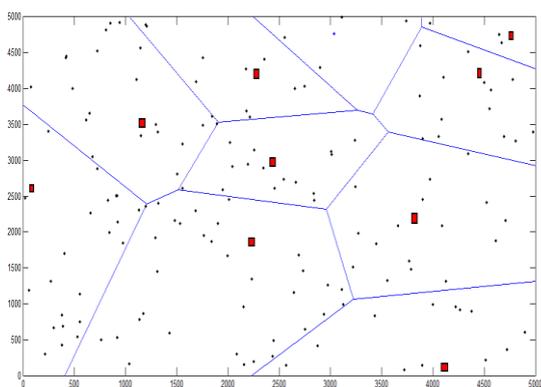


Fig. 1. A cellular network with Macro cell formed with a random tessellation

The edge effects are taken into accounts in the simulation. With limited simulation area, if a UE is located at the edge of the simulation area, the received power from nearby eNBs is not symmetrical. So to avoid the edge effects in the obtained results, the UEs who are located at this region are neglected and only UEs who are aligned at the center of the simulation area are considered.

The coverage area of each macro cell is calculated by considering the transmitted power of macro cell (47 dBm (40 watt) in the proposed scenario) and the interference from surrounding macro cells. With minimum signal detection threshold, the SINR is calculated at each X- Y point to get the more precise coverage area of macro cell.

User Association: the UE associates with eNB of highest RSRP received from surrounding eNBs. Each UE adds CIO value to the RSRP value. The CIO value is announced by each eNB according to SON algorithm with the aim of achieving load balance between cells and maximizing overall network throughput. Each eNB receive CQI from each UE then run the SON algorithm with its paired eNB at each direction. According to the output of the SON algorithm, it gets the suitable values of CIO which is declared after that.

According to the value of CIO of each user, the transport format of RB is identified and transmission rate is calculated. At each TTI, the RBs are scheduled between users according to proportional fair scheduling scheme.

Important Cell Parameters: The macro eNB's have evaluated with transmit power of 47 dBm (40 W). The cell bandwidth is 20 MHz in the 700 MHz LTE band. The macro heights are random based on actual deployment but it typically more than 25 m.

Traffic: in the simulation area, we randomly generate a UE with PPP density. We differentiate in PPP density between two types of cell: loaded cells and light loaded cells in order that SON run in suitable unbalanced environment. The traffic is randomly generated by those users with Poisson arrival rate $\lambda = 12$ requests/Sec. Each selected user has a FTP file with different size to evaluate the proposed algorithms at different network load.

• Model evaluation

In this part, the performance of the proposed SON algorithm is compared with benchmark schemes to further illustrate the improvement of network throughput with SON algorithm while maintain the load balance between cells. Two benchmark schemes are used: the first is a mobile network without SON between cells, the second is mobile network with normal SON which does not take the throughput into consideration. In the three scenarios, the same network settings is adopted.

Two performance metrics are taken into consideration: the first is the overall network throughput with different load adopted. The second is the load balanced between cells.

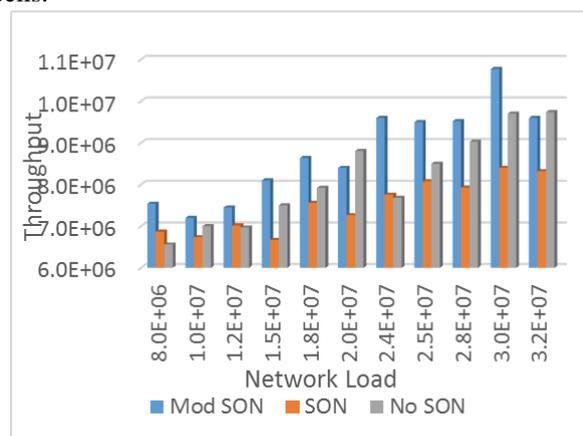


Fig. 2 Network throughput with different scenarios at different network loads.

Fig. 2 illustrates the overall network throughput for the three scenarios with different network load. It can be seen that the proposed scheme provide best network throughput. This is due to considering throughput with SON decision.

Fig. 3 compares between the three scenarios in cell load balancing. It is clear that the proposed scheme maintains the load balancing between cells almost or at some instants better than pure SON scenarios.

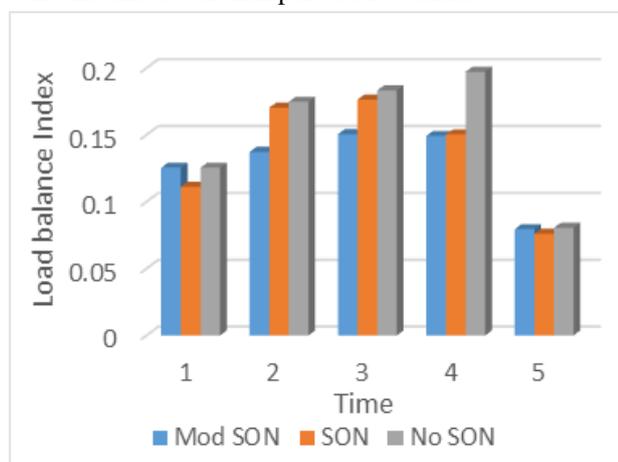


Fig. 3. Comparing between three scenarios with load balance index.

V. CONCLUSIONS

In this paper, a novel algorithm is provided for concurrent optimization for throughput, robustness while maintaining load balance between cells. The robustness is considered by assigning a maximum and minimum value of CIO that should not exceed. While the throughput and load balance are jointly optimized by pairing between nearby cells, then ranking selected users, and finally checking throughput state between paired cells. Results show that the proposed algorithm yields significant improvement in terms of robustness, throughput, and load distribution. More analysis is needed to consider the uplink capacity and robustness optimization in SON network which can be tackled in the future. This algorithm can be deployed with 5G environment by proposing several scenarios according to traffics demands which is left for future work.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

E. Serag and M Safwat proposed the new algorithm achieve load balancing in mobile network model based self-optimization network SON monitoring algorithm.

E. Serag and M Safwat supervised the research work, discussed the different scenarios and technical aspects related to the proposed model.

M. Safwat designed, verified and tested the Matlab code for the model. He provided the results and also

wrote both the proposed model and result parts in the paper. E. Serag wrote the introduction and surveying the related works. All authors approved the final version and helped shape the research.

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