Cooperative Successive Interference Cancellation for NOMA in Downlink Cellular Networks

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***Abstract*—A new cooperative interference harnessing technique is proposed for non-orthogonal multiple access (NOMA) aided downlink multicell networks. The technique, coined as cooperative successive interference cancellation (Coop-SIC), leverages on the optimality conditions for SIC in the multiple access channel (MAC) seen at the receiver side without superposition coding at the transmitter. We derive SIC gain conditions that determine when is beneficial to reduce one user's rate in order to enable SIC in another user potentially increasing its rate and maximize the sum-rate. The sum-rate maximization problem in multicell downlink systems is formulated and an algorithm to find the optimal solution is provided. Our simulation results show that our Coop-SIC technique is employed up to 80% of the iterations, providing up to 40% gains in the network's spectral efficiency.**

***Index Terms*—Cooperative cellular networks, NOMA, SIC, multicell downlink systems.**

I. Introduction

Among some radical transformations taking place in 5G cellular networks, new multiple access techniques have promised important gains in terms of coverage, cell edge rates, spectral efficiency, and reduced latency [1]. The well established information theoretic concept of multiple access [2], coined as Non-Orthogonal Multiple Access (NOMA) in 5G systems, has attracted significant attention in this context, showing promising system gains by concurrent transmissions and full resources reuse. NOMA and cooperative diversity are candidate solutions for grant-free access in massive Machine Type Communications (mMTC), reduced-latency access mechanisms for Ultra-Reliable Low-Latency Communications (URLLC), and spectral efficiency increase in Enhanced Mobile Broadband (eMBB) [3].

NOMA techniques can be divided depending on how signals are separated: in the power-domain or the coding-domain [4]. Power-domain NOMA techniques take place both in the downlink (broadcast channel - BC), and the uplink (multiple access channel - MAC). To achieve the capacity region in a BC, the transmitter should implement superposition coding and the receivers should employ successive interference cancellation (SIC). In contrast, for the MAC, only SIC at the receiver is required. In this paper, we propose a new NOMA technique, based on SIC for the downlink of cellular networks, without the need for complex transmit processing (spreading, superposition coding, power allocation). Instead of analyzing the BC formed by the transmitter and its different users in the same cell, we flip the system view and focus on the MAC formed by the desired and interference signals arriving at any receiver from different cells.

In practice, SIC receivers cannot be fully exploited in order to provide gains in the MAC formed by the desired signal and interference signals from other cells. This is mainly due to the use of non-cooperative link adaptation mechanisms in real-world cellular networks. If a user receives an interference signal, the user will highly likely be unable to decode it, because the rate has been adapted for the intended user, which of course is in its own cell. However, if a user accepts to lower its rate in order to allow a neighboring cell user to decode and cancel this signal, this will increase the neighboring user's rate. If the rate reduction is smaller than the neighboring user's rate increase, there is a net gain in the network sum-rate. This simple concept behind our scheme is called Cooperative SIC (Coop-SIC) for downlink cellular networks.

In a previous work [5], the Coop-SIC technique is analyzed for only one signal cancellation showing some promising gains especially for cell-edge users. The concept of reducing rates to enable interference cancellation is shown in [6]–[8]. In [9], the authors propose a new family of multiple access protocols based only on using SIC at the receivers to increase the number of active links in a network. The problem of link activation and cooperative transmissions with SIC is thoroughly analyzed for a general wireless network in [10]. Using only SIC it is also possible to maximize the set of signal-to-interference-plus-noise ratios (SINRs) in a wireless network as shown in [11].

In this paper, the conventional NOMA focus is switched from the BC to the MAC. We assume ideal multiuser detection receivers to take advantage of SIC and network cooperation to exploit SIC gains in cellular networks. Taking [5] as a baseline, our main contributions are: (i) analytic expressions are derived for sum-rate gain guarantees using Coop-SIC, i.e., users will not try to decode and cancel interference signals arbitrarily, but only in the cases where sum-rate is improved; (ii) the SIC gain conditions are derived for two important cases: (a) when a user decodes and erases several interference signals and (b) when several users decode and cancel the same interference signal; (iii) a non-linear optimization problem to maximize the sum-rate in downlink cellular networks is formulated; and (iv) finally, an algorithm to avoid an exhaustive search solution is proposed.

II. System Model

We consider the downlink of a N-cell network, where a single-antenna transmitter (Tx) serves a single-antenna receiver (Rx) at each cell. Txs are placed in hexagonal cells and operate as tri-sector base stations. For analytical convenience, we only consider distance-dependent pathloss attenuation and noise. Let $\hat{P}$ be the transmit power of each Tx and σ^2 be the variance of the additive white Gaussian noise. The transmit signal-to-noise ratio (SNR) is $P = \hat{P}/\sigma^2$ and the instantaneous received SNR from Tx_j at Rx_i is given by

$$P_{ji} = P\kappa_{ji}d_{ji}^{-\alpha} \tag{1}$$

where d_{ji} is the distance between Tx_j and Rx_i, $\alpha > 2$ is the pathloss exponent, and κ_{ji} denotes the channel gain including long-term propagation effects. For ease of exposition, the received SNR of the desired signal in the i-th cell user P_{ii} is denoted by P_i. Similarly, for the i-th cell user, the received SINR from the serving cell is SINR_i and the received SINR from an interference cell is SINR_{ji} as follows:

$$SINR_i = \frac{P_i}{1+\sum_{j\neq i} P_{ji}}, SINR_{ji} = \frac{P_{ji}}{1+\sum_{k\neq j} P_{ki}}. \tag{2}$$

III. Cooperative SIC

In downlink cellular networks, link adaptation mechanisms aiming to increase the transmission rate reduce the utility of SIC receivers for interference cancellation. Since a neighboring cell user experiences lower capacity in any interference signal channel, the interference message cannot be decoded at the receiver side. Network cooperation can overcome this problem as shown in [5] for a 2-Tx and 2-Rx network.

A. Baseline results: Cooperative SIC in 2 cells

Network coordination enables to identify when the rate of one user should be reduced so that its signal can be canceled by another user, who in turn may potentially increase its own rate. The necessary and sufficient conditions to guarantee sum-rate gains using SIC at the i-th user are as follows:

1) Verify that the following inequality holds

$$P_{ji} > \frac{P_j}{1+P_{ij}} \tag{3}$$

2) Transmit at rates bounded satisfying

$$\begin{aligned} R_i &\leq C(P_i), \\ R_j &\leq \min\left\{C\left(\frac{P_j}{1+P_{ij}}\right), C\left(\frac{P_{ji}}{1+P_i}\right)\right\} \end{aligned} \tag{4}$$

where $C(x) = \log_2(1+x)$ is the Shannon rate function (spectral efficiency)(in bps/Hz).

The inequality in (3) can be interpreted as follows. Whenever the interference from user j is stronger than the j-th user's SINR, it is worth decoding and canceling this interfering signal. In that case, as shown in (4), the i-th user can transmit at its single-user capacity (interference-free rate), while the j-th user should transmit at a rate allowing decoding both by itself and the i-th user. The stronger the interference, the larger the gains obtained after its cancellation.

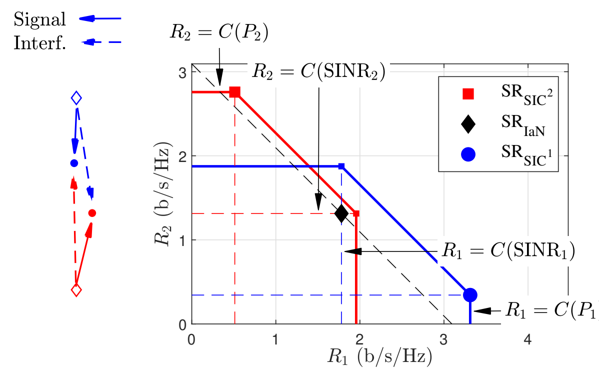

Fig. 1. MAC capacity regions formed by 2 Tx-Rx pairs. Both regions have points above the SR_{IaN} black dashed line (both SIC gain conditions are met).

Figure 1 illustrates the capacity regions for the MACs in a 2-Tx 2-Rx network (the blue and red users receive one desired and one interference signal each). The SR_{IaN} shown in the black diamond is the pair of rates that adds to the sum-rate for both users treating Interference-as-Noise (IaN). All points in the black-dashed line add to the same sum-rate. The blue circle shows the pair of rates (which adds to SR_{SIC^1}) achieved when the blue user performs SIC to cancel interference from the red user. Similarly, the red square shows the rates for performing SIC at the red user. Both SR_{SIC^1} and SR_{SIC^2} are greater than SR_{Ian} hence, both SIC gain conditions are satisfied. There are three important remarks for the 2-Cell Cooperative SIC scheme, which are also valid for the general case of more than two cells: (i) The corner points in the MAC capacity region are optimal, since they achieve the maximum sum-rate. However, according to the bounding rates condition in (4) one of the rates might not be achieved in order to allow signal cancellation. (ii) The blue and red corners closer to the black diamond are meaningless for Cooperative SIC, because they imply a decoding order that allows getting the non-desired signal (from a non-serving cell) with an interference-free rate. (iii) Under this Cooperative SIC scheme, SIC is not used randomly, but is activated only whenever sum-rate gains are guaranteed. To guarantee these gains, the rates in (4) are mandatory and they result in allowing one user to use its SIC capability. Henceforth, only one user can perform SIC at a time. If the red user performs SIC, the pair of rates should be those in the red square; if the blue user performs SIC, the pair of rates should be those in the blue circle.

IV. Cooperative SIC in $N \geq 2$ cells

We now extend the SIC gain condition in (3) to the general case where N Tx-Rx pairs interfere with each other. In that case, a SIC receiver could successively decode and erase up to $N-1$ interference signals.

***Proposition** 1: The necessary and sufficient conditions to perform SIC at the u-th user so as to increase the sum-rate in an N-cell network compared to the sum-rate when interference is treated as noise are:*

1) *The following inequality holds*

$$1 + \sum_{j \neq u}^{N} P_{ju} > \prod_{i \neq u}^{N} \left(1 + \mathrm{SINR}_i\right). \tag{5}$$

2) *Transmit at rates*

$$R_u \leq C(P_u),$$
$$R_{k \neq u} \leq \min\left\{ C\left(\frac{P_{ku}}{1 + \sum_{j=1}^{k-1} P_{ju}}\right), C\left(\mathrm{SINR}_k\right)\right\}. \tag{6}$$

Proof: The u-th user (Rx_u) receives signals from N cells, so to achieve the maximum capacity in this MAC, we need to perform $N-1$ SIC iterations, and transmit at the N rates forming a corner of the capacity region of the MAC at Rx_u:

$$\left[C\left(P_u\right), C\left(\frac{P_{1u}}{1+P_u}\right), \dots C\left(\frac{P_{Nu}}{1 + \sum_{j \neq N}^{N} P_{ju}}\right)\right],$$

Similarly to (4), all rates of signals decodable at the u-th user should also allow decoding at the users receiving its signal. The system operating rates with N Tx-Rx pairs are shown in (6). The sum of these rates is again denoted as $\mathrm{SR}_{\mathrm{SIC^u}}$. In the worst possible case for SIC gain, where the sum of the SIC rates is very close to $\mathrm{SR}_{\mathrm{IaN}}$, all receivers $k \neq u$ get the IaN rates $R_{k\neq u} = C\left(\mathrm{SINR}_k\right)$. However, the SIC gain condition holds true since

$$\begin{aligned} \mathrm{SR}_{\mathrm{SIC^u}} &> \mathrm{SR}_{\mathrm{IaN}} \\ C\left(P_u\right) + C\left(\mathrm{SINR}_1\right) \dots + C\left(\mathrm{SINR}_N\right) &> \sum_{i=1}^{N} C\left(\mathrm{SINR}_i\right) \\ C\left(P_u\right) &> C\left(\mathrm{SINR}_u\right). \end{aligned}$$

Yet, the largest difference in $\mathrm{SR}_{\mathrm{SIC}} > \mathrm{SR}_{\mathrm{IaN}}$ will be obtained if all rates are equal to the maximum decodable rate according to the MAC channel formed by the N signals arriving at Rx_u. From (5), this implies that $R_{k\neq u} = C\left(P_{ku}/(1 + \sum_{j=1}^{k-1} P_{ju})\right)$. In that case, the SIC gain condition can be expanded as

$$C\left(P_u\right) + C\left(\frac{P_{1u}}{1+P_u}\right) \dots + C\left(\frac{P_{Nu}}{1 + \sum_{j \neq N}^{N} P_{ju}}\right) > \sum_{i=1}^{N} C\left(\mathrm{SINR}_i\right)$$

$$\left(1+P_u\right)\left(\frac{1+P_u+P_{1u}}{1+P_u}\right) \dots \left(\frac{1+\sum_{j=1}^{N} P_{ju}}{1+\sum_{j\neq N}^{N} P_{ju}}\right) > \prod_{i=1}^{N} \left(1 + \mathrm{SINR}_i\right),$$

then, after some algebraic manipulations, we get the *General SIC Gain Condition* (SIC-GC in the sequel) in (5), which concludes the proof.

A. Cooperative SIC Orders

In the downlink cellular network with N Tx-Rx pairs, we find N MACs, one per receiver. Each of these N-signal MACs has a known capacity region: a polyhedron in $\mathbb{R}^N$ composed of $2^N - 1$ hyperplanes. Each hyperplane is formed by an inequality of the form

$$\sum_{i \in \mathcal{S}} R_i < C\left(\sum_{i \in \mathcal{S}} P_i\right), \tag{7}$$

where $\mathcal{S}$ is any non-empty subset of the set $[1 \dots N]$. The resulting polyhedron has $N!$ corners, one per each possible decoding order, but not all decoding orders are suited for Coop-SIC. The desired signal should be last in terms of decoding order. Additionally, as it can be observed in Figure 2, in a network with N Tx-Rx pairs, some signals can be used for Coop-SIC and the rest can be left as Other-Cell-Interference (OCI). If a network operates at any corner in a MAC formed by $n \leq N$ signals (i.e., where a user decodes and erases $n-1$ signals), we say it applies a Coop-SIC transmission of *n-th order*. Notice that for any N Tx-Rx pairs network, there are $\binom{N}{n}$ MACs of order n, with $2 \leq n \leq N$. Increasing the Coop-SIC order shrinks the area where the SIC-GC is valid, but it also increases the sum-rate gains with respect to IaN.

B. Gains and Fairness of Coop-SIC using the SIC-GC

The general SIC-GC has a similar interpretation as in the two-cell case. Neighbors with low SINR and users near cell edges are opportunities for SIC receivers.

To get some intuition of the gains obtained using Coop-SIC, let us assume that all received SNRs $P_{ij}, \forall i, j$ are equal to p. Note that $\mathrm{SINR} = p/(1+(N-1)p)$. When $N = 3$, $\mathrm{SR}_{\mathrm{IaN}} = 3 \times C(\mathrm{SINR})$, but the sum-rate using SIC is $\mathrm{SR}_{\mathrm{SIC}} = C(p) + C(p/(1+p)) + C(\mathrm{SINR})$. The larger the value of p (the more interference clogging up the network), the higher the gains. However, the gains would start vanishing if not all users receive approximately the same SNR from the different Txs. Figure 2 shows how sensitive to the users'

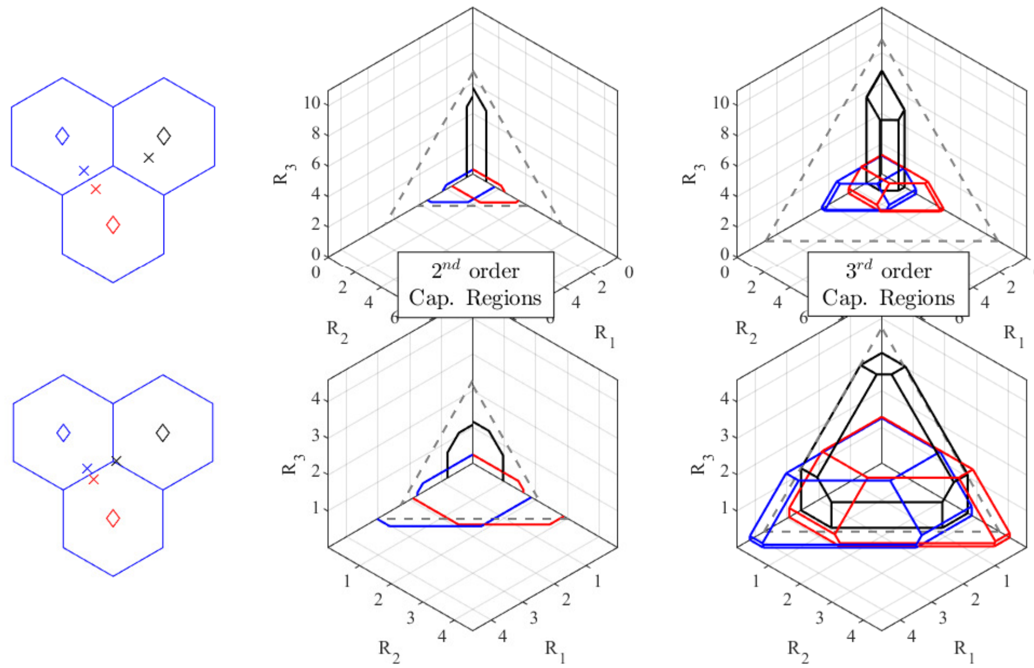

Fig. 2. Capacity regions for MACs of order 2 and 3 formed in a 3-cell network. In the bottom case, users are closer to the cell edge: two 2^{nd} order and all three 3^{rd} order conditions get activated.

positions these gains can be. In the top case, none of the SIC-GCs is activated for $n = 2$ nor $n = 3$, where n is the number of signals canceled using SIC. In the bottom case, moving the third user closer to both Tx_1 and Tx_2 activates several SIC-GCs for $n = 2$ and $n = 3$. However, as more signals are canceled by one user, these transmission technique becomes increasingly unfair: one user gets an interference-free rate, whereas the others get rates adapted so that the user performing SIC can decode those signals. Time sharing between several SIC receivers (if all SIC-GC are active) could be a good strategy to adjust the scheme's fairness. Using different decoding orders could also help improve fairness, but for the sake of brevity, we omit those schemes in this paper.

C. Extending the SIC Gain Condition

The SIC-GC described in (3) does not include all the cases where a network can take advantage of SIC receivers. Let us consider the following simple case for illustration. In a network with $N = 3$ Tx-Rx pairs, Rx_1 and Rx_2 cannot cancel Rx_3's signal, because none of the SIC-GC holds true. However, we can identify an *extended* form of the SIC Gain Condition. Tx_1 and Tx_2 will both send rates as if Tx_3's signal could be canceled at Rx_1 and Rx_2, that is $R_1 = C(P_1/(1+P_{21}))$ and $R_2 = C(P_2/(1+P_{12}))$, then, Rx_3 rate should be the minimum between all rates than can be decoded at all Rxs: $\min\{C(\text{SINR}_{31}), C(\text{SINR}_{32}), C(\text{SINR}_3)\}$. This extended SIC Gain Condition (eSIC-GC) is different from the one described in (3). In the general SIC-GC, one Rx decodes and erases $N-1$ interference signals. In the eSIC-GC, only one signal is actually decoded and erased by $N-1$ Rxs. Therefore, we generalize the eSIC-GC in the following result.

***Proposition** 2: A necessary and sufficient condition to decode and cancel the x-th user signal in all other $N-1$ users so as to increase the sum-rate compared to the interference-as-noise sum-rate is*

$$\left(\frac{1+\sum_{i\neq l} P_{il}}{1+\sum_{i\neq l,x} P_{il}}\right) \prod_{k\neq l,x} \left(\frac{1+\sum_{i\neq x} P_{ik}}{1+\sum_{i\neq k,x} P_{ik}}\right) > \prod_{j\neq l}(1+\text{SINR}_j), \tag{8}$$

where the rate for the x-th user should be bounded by

$$C\left(\frac{P_{xl}}{1+\sum_{i\neq x} P_{il}}\right) = \min\left[\bigcup_{k\neq x} C\left(\frac{P_{xk}}{1+\sum_{i\neq x} P_{ik}}\right)\right] \tag{9}$$

Proof: The proof follows similar derivation as in Proposition 1 and is omitted due to space limitations.

The intuition behind the above extended condition is that the neighbors of a low-rate user will try to decode and cancel that user's signal as a means to decode their own ones at a higher rate. To do so, they need to guarantee that the x-th user's signal can be decoded based on equation (9). The inequality in (8) guarantees gains in terms of sum rate. If another user's signal is to be cancelled by several Rxs, the set of rates needed in order to guarantee gains changes completely, thus, only one eSIC-GC can be executed by any cell at a time. As seen in Figure 3, cells $4, 5$ cancel cell's 6 signal, whose user is at cell edge.

V. Network Scheduling

The use of Coop-SIC exploiting the SIC-GC and eSIC-GC in the downlink of a cellular network sets an important optimization challenge. As shown in [5], a centralized algorithm (all P_{ij} known) should be able to evaluate and decide which of the possible cells should operate in Coop-SIC and under which SIC-GC or eSIC-GC. The notation described in [5] is reused with the following definitions.

- *Master cell (M)*: a Tx-Rx pair that imposes a rate to another cell in order to perform SIC and decode the interfering signal.
- *Slave cell (S)*: a Tx-Rx pair whose rate is imposed by a master cell.

In order to apply Coop-SIC when SIC-GC and eSIC-GC are valid, a scheduler that maximizes the network's sum-rate should fulfill the following conditions:

- A master cell cannot be a slave cell simultaneously.
- A master cell has only one unique set of slaves.
- A slave cell may have several masters if an eSIC-GC applies.

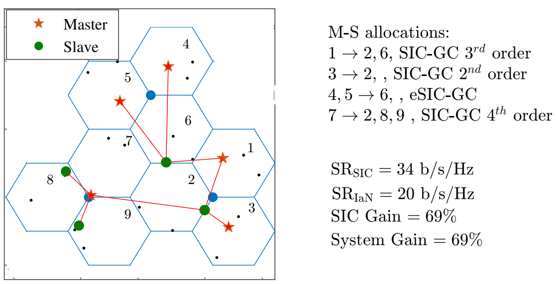

Fig. 3. 9-cell network layout. Users are placed randomly, arrows indicate Master-Slave relations.

A. Optimization problem

The network sum-rate should be maximized by activating some SIC Rxs, as stated in the following non-linear optimization problem:

$$\max_{X_i, X_k} \quad \sum_{i=1}^{N} \sum_{\mathcal{M}} R_i^A X_i^A + \sum_{k \neq i} R_k X_k \tag{10a}$$

$$\text{s.t.} \quad X_i^A \cdot X_j^B = 0, j \in A \setminus B, \tag{10b}$$

$$X_i^A \cdot X_i^B = 0, i \notin A \cup B \tag{10c}$$

where $\mathcal{M}$ is the set of all possible subsets of masters and $A, B \subset \mathcal{S}$. R_i^A is the SIC rate imposed by the subset A to the user in cell i, X_i^A is a binary decision variable indicating if SIC is used in the slave i, R_k is the IaN rate for the user in cell k and X_k is a binary decision variable for non-SIC cells (i.e. the cells that are not masters or slaves and will operate in IaN mode). Constraint (10b) implies that a master cell cannot simultaneously be a slave cell. Constraint (10c) means that the set of masters is unique for a given slave. To solve this non-linear optimization problem avoiding an exhaustive search among all possible combinations of masters and slaves, all possible SIC-GC and eSIC-GC are evaluated, and all possible Masters-Slaves sets that do not violate the constraints in (10b)(10c) are evaluated to find the optimum

TABLE I
SIMULATION PARAMETERS AND VALUES.

Parameter	Value
Inter-BS distance (km)	0.5
Min BS-UE distance (km)	0.02
Pathloss (d in km)	$148.1 + 37.6 \log_{10}(d)$ dB
Horizontal CAP, θ in (°)	$-\min(12(\theta/70)^2, 20)$ dB
Noise power + Noise figure	-174 dBm/Hz + 9 dB
Link budget adj.	-7 dB.

sum-rate. This brute force solution remains in low execution time for a network with $N = 9$ and $n \leq 4$, since the number of combinations is reduced from ~ 1 billion to ~ 2 million.

Algorithm 1 Sum-rate maximization using Coop-SIC in multi-cell networks

$N \Leftarrow$ number of cells.
1. Create all Slave (S) combinations for each possible Master (M).
for all $n = 1$ to N **do**
  Check possible Slaves.
end for
return $\mathcal{S} \Leftarrow$ set of all Slaves, where $s = |\mathcal{S}|$.
2. Check SIC-GCs for all M-S combinations in $\mathcal{S}$.
for $i = 1$ to s **do**
  $1 + \sum_{j \neq u}^{n} P_{ju} > \prod_{i \neq u}^{n} (1 + \mathrm{SINR}_i)$.
end for
return $\mathrm{SIC}_{\mathrm{list}}$, where $L = |\mathrm{SIC}_{\mathrm{list}}|$.
3. Create all Masters combinations for each possible Slave.
for all $n = 1$ to N **do**
  Check possible Masters.
end for
return $\mathcal{M} \Leftarrow$ set of all Masters, where $m = |\mathcal{M}|$.
4. Check eSIC-GCs for all M-S combinations in $\mathcal{M}$.
for $i = 1$ to s **do**
  Eval eSIC-GC in (9).
end for
return Update $\mathrm{SIC}_{\mathrm{list}}$.
5. Find the best M-S set of combinations
for all $l = 1$ to L **do**
  Find all M-S conflicts (optimization constraints) where:
  $conflict_1 := \{(S_l, M_l) | S_l \in \mathcal{M} \cup M_l \in \mathcal{S}\}$
  $conflict_2 := \{A_l, B_l \in \mathcal{M}\}$ for the same S.
end for
return $\mathrm{Conflicts}_{\mathrm{list}}$ where $C = |\mathrm{Conflicts}_{\mathrm{list}}|$
return $V = \prod_j^C |conflict_j|$ where V is the number of valid M-S combinations.
for $i = 1$ to V **do**
  Calculate the system sum-rate
end for
return $\mathbb{A}$ the set of the optimal M-S allocations for problem (10).

VI. NUMERICAL RESULTS

A network of 3 tri-sector BSs forms a 9-cell hexagonal grid as shown in Figure 3. The number of neighbor cells varies from cell to cell. The system parameters are based on a 3GPP simulation scenario case 1 described in [12]. Its main values are summarized in table I.

The SIC success rate shown in Figure 4 indicates the average percentage of cells involved in the Coop-SIC scheme (either as master or slave) at any iteration. The eSIC-GC allows an important increase in the success rate over SIC-GC. Both conditions show some increase in success rate as the SNR increases except for SIC-GC $n = 2$. This is due to the tri-sector network layout, that creates a severe OCI in a 2^{nd}-order SIC-GC. Additionally, $n = 4$ adds only marginal gains. This marginal increase can also be observed in Figures 5 and 6, emphasizing the strong dependence of the Coop-SIC transmission on the network topology. Using other topologies $n > 3$ might add more gains. When SIC-GC are evaluated, the predominant orders are $n = 3, 4$ taking up to 85% of the SIC-GC cases. When the eSIC-GC is also active, the predominant order is $n = 2$ with up to 50% of the Coop-SIC cases. In Figure 5, increasing the number of users per cell U translates into important gains in sum-rate (wrt IaN) for both SIC-GC and eSIC-GC. The latter condition for $U = 3$ and $n = 3, 4$ increases the IaN sum-rate nearly 50%. In Figure 6 the system gain (the total sum-rate increase of the 9 cells) is compared to the SIC gain (the sum-rate increase of those cells in Coop-SIC) which shows that only using cooperative rate reduction and SIC receivers an average 40% system gain can be obtained.

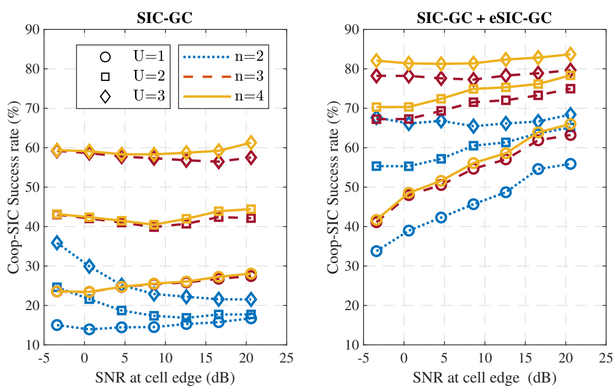

Fig. 4. Coop-SIC Success Rate: percentage of the cells operating any Coop-SIC transmission.

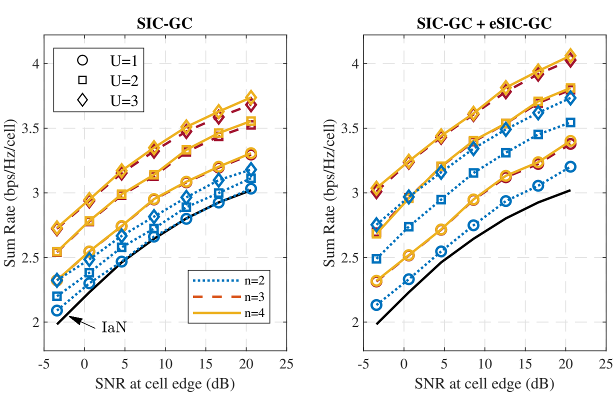

Fig. 5. Per cell sum-rate: IaN vs. Coop-SIC $n = 2, 3, 4$ and users per cell $U = 1, 2, 3$.

VII. Conclusions

We introduced a new interference mitigation scheme for NOMA-aided downlink multicell systems, which leverages on deriving SIC gain conditions for the MACs seen by the users flipping the system view at the receiver side. Our method guarantees gains in terms of sum rate using cooperative rate reduction mechanisms to enable SIC. Our simulation results show up to 40% gains in average sum-rate with respect to IaN, without the need for power-domain NOMA with superposition coding. These gains strongly depend on the network topology and irregular and/or cell-free layouts could lead to higher gains.

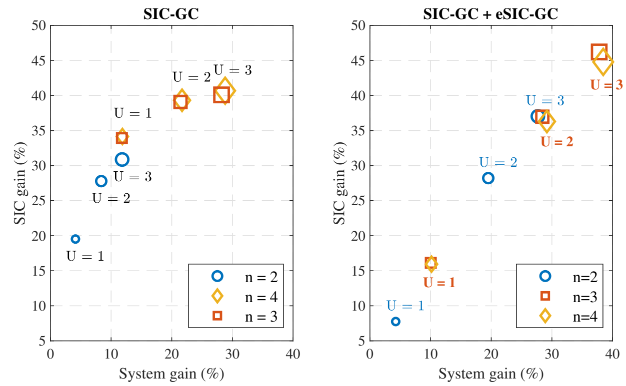

Fig. 6. SIC gain vs. System gain for Coop-SIC orders $n = 2, 3, 4$ and users per cell $U = 1, 2, 3$ with SNR $= 5$ dB at the cell-edge.

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