Multi cell Coordination via Scheduling, Beamforming and Power control in MIMO-OFDMA

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Abstract - ***A big challenge for wireless networks is to increase the cell edge performance and support multi-stream transmission to cell edge users. The objective of this project is on hand to give service to users of the edges of cells that are affected by the interference between cells and improve cell performance edge. Technology Based mitigation are multiple antennas and coordination between now strongly cells are studied in the literature. Typical strategies include programming in OFDMA networks, beamforming coordinated scheduling and power control. In this work, we are implementing a new and practical coordination cell multiple OFDMA downlink and scheduling for networks that rely multiple antennas at the transmitter and receiver there. The transmission lines, that is, the number of transmission streams, and user programming in all cells are optimized to jointly maximize a utility function network representing equity among users. The scheme works implemented based on user postponing a recommended for interfering cells that explain the ability of interference suppression receiver range. This incurs a very low feedback and allows efficient backhaul overhead and link adaptation. Moreover, it is robust to channel measurement errors. A 9% cell edge performance gain over uncoordinated LTE-A MMSE IRC is shown through system level simulations.***

Key Words: *Multiple-Input Multiple-Output (MIMO), Orthogonal Frequency Division Multiple Access (OFDMA), cellular networks, Rank recommendation based coordinated scheduling, MMSE IRC, Cell average Throughput, Cell edge Throughput.*

I. INTRODUCTION

In today's wireless networks, users of the edges of cells experiencing low signal-to-interference and noise (SINR) due to high Inter-cell Interference (ICI) and cannot fully benefit of Multiple-Input Multiple-Output (MIMO) capability multi-stream transmission. Reduction technologies Relying advanced multi-cell interference are co have attracted much attention in the industry and academia recently. This technique, commonly indicated as Coordinated transmission and reception (COMP) in 3GPP LTE multi-point, [2] are classified in the processing of joint scheduling (Based on data exchange between cells) and coordinated / programming beamforming (It does not require data exchange between cells).

This paper focuses on the second category does not require data exchange. Three types of cooperation of multiple cells are usually investigated, i.e. coordinated beam-forming [4-5] Coordinated programming [6-7] and power control Coordinated [8-9]. These types of cooperation can be carried out independently or combined.

Unlike previous studies that targeted optimal designs under ideal circumstances, other papers have focused on increasing cooperation schemes multi-cell under less than ideal circumstances. In [14] grouping is used to decrease the general feedback and planner Reduce complexity and the number of cells that cooperate in conserving as possible to the action. In [15] beamforming transmission is designed to account for imperfect CSI model as noisy channel estimates. Limited feedback is considered and the feedback bits are shared between cells in order to minimize performance degradation caused by the quantization error. In an iterative algorithm it is designed to optimize allocation of downlink beamforming and power-efficient systems duplex backhaul limited time division (TDD).

This paper provides a novel and a cooperation scheme with multiple practice cells joined Based user programming and rank coordination Such rows of transmission of the of which (i.e, the number of transmission streams) are coordinated between cells to maximize a utility function of the network. In theory, a system of this type of cooperation is a sub-issue of the more general problem of coordinated programming united, beamforming control and power when the SRS control transmission lines to optimize years ON / OFF power allocation in each direction of beam forming. We could therefore adopted an iterative. The programmer similar to that used in [12-13]. However, this work has resulted AIMS much simpler and practical framework that directly addresses the problem of user programming and coordination range without heavy machinery required iterative planning. Also to overcome the disadvantage of coordinated planning algorithm based recommendation range, the proposed scheme implements the method of successive interference cancellation.

On the terminal side, the coordination scheme rank retrofitted on the report from the user terminal a range of preferred interference, referring to the transmission range in the interfering cell that maximizes user performance of victims, and differential channel quality indicator (CQI).

Beside the network, using a coordinated planner appropriate motivated by a mechanism of pricing similar to [9] interference and Relying was master-slave architecture cells coordinate with each other to make informed decisions about the scheduled users and transmission ranges That would be the least harmful to users in neighboring cells victim. In iterative planner, multiple iterations are required to converge (if convergence is achieved). The final programming decisions are obtained only after a long latency as each iteration requires users to wait for the report. For reference, it requires about 500 iterations (50 iterations where each iteration consists of 10 sub-iterations) before convergence to coordinate power between cells. These interactions between users and their extensive EB significantly increase the complexity and overhead of the network and synchronization requirements and backhaul, which is not practical. The master-slave planner reviews coordinated elsewhere that operates in a more distributed manner and retrofitted exchange only in some low overhead messages between cells. It is also less sensitive to convergence problems.

The paper is organized as follows. Section II model system is detailed. The principles and implementation details of the coordinated range-based programming recommendation are described in sections III and IV. Section V illustrates the achievable benefits of the proposed system based on system-level assessments.

II. SYSTEM MODEL

Assume a downward link MIMO-OFDMA multi-cell network with a total number K distributed in cellsn_c, with each cell users$K_{,i}$, in cell i, T subcarriers, antennas n_t conveyed to each BS, n_r receive antenna in each mobile terminal users. It assumes that MIMO Among the cellular channel i, q is k subcarrier usually independent of the subcarrier scale.

The user models fading MIMO channel process and $\square_{q,i}$ small scale refers to the large scale fading (shadowing and path loss). Note that the large scale fading is typically independent of the subcarrier.

The serving cell defined as the cell control information transmitting downlink. We define the set I served user cell called K_i with cardinality K_i = K_i, as all users who have served have cell phone. We also define the scheduled user set of cells on subcarrier k, denoted as $K_{k,i} \subset K_{,i}$, as the subset of users actually ∈ K_i about scheduled a subcarrier k at any time.

The architecture implemented was subsequently joined master-slave distributed architecture and recommendation interference caused by the lead in the next section range. Performance evaluations in Section VI demonstrate the benefits of the row recommendation compared to the heavy machinery of coordinated programming iterative beam forming and power control in a realistic setting.

III. COORDINATED MULTI-CELL RESOURCE ALLOCATION

Contrary to a non-cooperative network, a cooperative scheme dynamically coordinated coordinates Based classify users in all cells and frequency resources may range from that of the transmission of a given cell and frequency resource is favorable for performance users of that cell and adjacent cells victim of users on the frequency resource Sami scheduled. In this section, the resource allocation problem is related to range Discussed coordination and architectural planner interference caused by the pricing mechanism is introduced year.

A. MOTIVATION FOR THE SCHEDULER ARCHITECTURE

For a fixed user schedule, the optimal rank allocation problem must satisfy the Karush-Kuhn-Tucker (KKT) conditions. The Lagrangian of the optimization problem dialyzed with respect to the rank constraint writes as

$$L(J,K,v,u) = \sum_{j=1}^{n_c}\sum_{k=0}^{T-1}[T_{k,j} + v_{k,j}\left(L_{max,j} - L_{k,j}\right) + \mu_{k,j}(L_{k,j} - L_{min,j})] \quad (1)$$

Where $v = \{v_{k,j}\}_{k,j}$ and $\mu = \{\mu_{k,j}\}_{k,j}$are the sets of nonnegative

Lagrange multipliers associated with the transmission rank constraints in each cell and each subcarrier.

For any I = 1, . . . , $n_c$and k = 0, . . . , T − 1, the solution should satisfy

$$\frac{\partial L}{\partial L_{k,i}} = 0 \quad (2)$$

$$v_{k,i}\left(L_{max,i} - L_{k,i}\right) = 0, \mu_{k,j}\left(L_{k,j} - L_{min,j}\right) = 0$$

$v_{k,i}$ ≥ 0, and $\mu_{k,j}$ ≥ 0.We can proceed with (2) as

$$\frac{\partial T_{k,i}}{\partial L_{k,i}} - \sum_{m \neq i, s \in K_{k,m}} w_s \pi_{k,s,m,i} = v_{k,j} - \mu_{k,j} \quad (3)$$

where we define

$$\pi_{k,s,m,i} = -\frac{\partial T_{k,s,m}}{\partial L_{k,i}} \quad (4)$$

Let us first define $I^*_{k,s,i}$ as the transmission rank in cell$i$ that maximizes the throughput $T_{k,s,m}$of user s in cell m assuming a predefined set of transmission ranks $L_{k,j}$in all Cells $j \neq i$

$$I^*_{k,s,i} = arg_{L_{min,i} \le L_{k,i} \le L_{max,i}} max T_{k,s,m}(L_{k,i}, \{L_{k,j}\}_{j \neq i}) \quad (5)$$

Note that if the network decides to configure $L_{min,i}$= 0, all users will choose their preferred interference rank as being equal to 0, so as not to experience any interference. Interestingly, the condition (3) can be viewed as the KKT condition of the problem where each cell *I* tries to maximize on subcarrier *k* the following surplus function

$$\gamma_{k,i} = T_{k,i} - \pi_{k,i} \quad (6)$$

With

$$\pi_{k,i} = \sum_{m \neq i} \sum_{s \in K_{k,m}} (L_{k,i} - I^*_{k,s,i}) w_s \pi_{k,s,m,i} \quad (7)$$

Equation (6) has an interference pricing interpretation and suggests that the cell *i* can decide upon the set of co-scheduled users and the transmission rank on subcarrier *k.*

IV. RANK RECOMMENDATION-BASED COORDINATED SCHEDULING

Motivated by the pricing mechanism of interference, we drift in this section Some guidelines for the recommendation based coordinated range planner who coordinates transmission lines and stored in the network and to calculate the local level (hopefully) L users optimum and L^*, K^* based on recommendations made by the terminals.

Observation 1: Each time a given cell planner application that accepts a range of interference i recommended $I^*_{k,s,i}$ at the instant of time t, k resources more often the victim user s m in the next cell who reported interference range recommended $I^*_{k,s,i}$ to the cell that has to be programmed at the time Sami time t in the frequency resource Same k.

A. A MASTER-SLAVE BASED SCHEDULER ARCHITECTURE

The coordinated planning is based on a master-slave asynchronous architecture motivated by Observation 1. In each instant of time BS acts only as the Master (indicated as M) and the other is the slave BS (denoted as S). The Master BS, based on the reports of interference preferred range, decides a transmission range $L_{k,M}$ ∀k constant, that is, its users $L_{k,M}$ = L_M, and schedules such that the rows of transmission are all scheduled users as much as possible equal to L_M. The BS Slave Master knowing the BS recommended accept some degree of interference schedule with the highest priority to users who requested CoMP coordination Master BS range.

1) Master BS decision on the transmission rank: The Master BS, upon reception of all information, $I^*_{l,M}$and all the effective QoS $\tilde{\omega}_{k,l,M}$ of victim users *l*, with $l \in \{K_{S_1} K_{S_1}\}$, sorts those interference ranks by order of priority. In a given cell i, the vector $I_1^{(i)}, I_2^{(i)}, ... I_n^{(i)}$ denotes the priority of the interference ranks. For instance $[I_1^{(1)}, I_2^{(1)}, I_3^{(1)}, I_4^{(1)}]$=[2,1,3,4] indicates that a recommended interference rank equal to 2 is the most prioritized in cell 1. Master BS M decides upon the transmission rank L_M and allocates one transmission rank for each sub-frame where the BS acts as a Master BS. By doing so the each Master BS defines a cycling pattern of the transmission ranks with the objective of guaranteeing some time-domain fairness. The priority and allocation of the transmission ranks accounts for the relative number of rank recommendation requests per rank.

Let us illustrate the value of L_M in a given cell *i* changes as time (sub frame) goes by following the cycling pattern $I_1^{(i)}, I_2^{(i)}, I_1^{(i)}, I_2^{(i)}, I_3^{(i)}$ indicating that whenever cell 1is the Master BS, BS 1 transmits with rank L_M= $I_1^{(i)}$=2, L_M=$I_2^{(i)}$=1, L_M=$I_1^{(i)}$=2, L_M=$I_2^{(i)}$=2 and L_M=$I_3^{(i)}$=3 in sub-frames. BS 2 and 3 operate in similar manner.

2)*Master BS scheduler operations:* In cell M, we divide users into two subgroups:

1. $\mu_{M,1} = \left\{q \epsilon K_M ▯ R^*_q = L_M\right\}$, i.e. the set of users in cell M whose preferred rank indicator is equal to the transmission rank L_M.
2. $\mu_{M,2} = K_M / \mu_{M,1} = \{q \in K_M ▯ q \nexists \mu_{M,1}\}$, i.e. the other users.

At a given time instant, the scheduling in cell M is based on proportional fairness (PF) in the frequency domain till all frequency resources are occupied:

1. $\mu_{M,1} \neq$ ▯, schedules only users belonging to $\mu_{M,1}$.
2. $\mu_{M,1} =$ ▯, schedules only users belonging to $\mu_{M,2}$.

3) Slave BS scheduler operations: In cell S*i*, *i* = 1, 2, we define three subgroups:

1) The set of CoMP users ∈S*i* who recommend cell M and whose preferred interference rank is equal to the transmission rank L_M as $\mu_{S_i,1} = \{q \in P_{S_i} | M \in M_q, I^*_{q,M} = L_M\}$.

2) The set of all other CoMP users ∈S*i*, i.e. who either do not recommend cell M or recommend cell M but whose preferred interference rank is not equal to the transmission rank, is defined as $\mu_{S_i,2} = \{q \in P_{S_i} / M \notin M_q\} \cup \{q \in P_{S_i} / M \in M_q, I^*_{q,M} \neq L_M\}$.

3) The set of non-CoMP users in $S_i$is defined as $\mu_{S_i,2} = K_{S_i} / P_{S_i}$.

Scheduling in cell S*i* is performed as follows:

1. If $\mu_{M,1} \neq$ ⍰, schedules only users in the order of priority; $\mu_{S_i,1}, \mu_{S_i,3}, \mu_{S_i,2}$.
2. $\mu_{M,1} =$ ⍰, schedules all users without any priority.

A second dynamic cycling pattern$I_1{}^{(i)}, I_2{}^{(i)}, I_1{}^{(i)}, I_3{}^{(i)}$, is also investigated where more stress is given to cell edge users as the last entry of the pattern has been switched to I_1. Contrary to the first pattern, the second pattern has a non-negligible cell average throughput loss because$I_2{}^{(i)}$and $I_2{}^{(i)}$are most of the time equal to 1 and 2 ∀*i*, and, therefore, users in the Master cell with the preferred RI equal to 3 and 4 have few chance to be scheduled.

Figure 1 shows, the programming for Allocated victim provide users with the service. Here the master-slave architecture is used to provide effective communication between them users. Only one station acts as a master station and parts thereof assigned user information to the home base station. Assigned subcarrier the user only when the degree of interference preferred equal to transmission range, If Is there any interference then provides information to the user and then the programming is done from the beginning, i.e. reducing peak average power ratio and search And then the best rated programming.

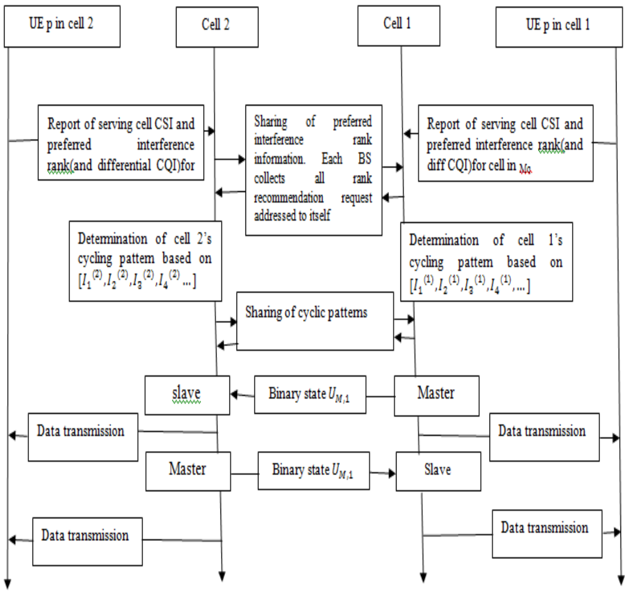


Figure.1: Overview of the architecture of the rank recommendation based coordinated scheduling.

With User Recommendation, the master-slave architecture planner does not experience the convergence and complexity of the iterative planning issues [12], [13]. It benefits of link adaptation by calculating a CQI user terminal in cooperation representing application and multi-cell receptor and incurs a very small feedback overhead. Moreover, thanks to the postponement of the interference I recommended range, ka resources q cell edge user is scheduled may experience Superior transmission range. Proper selection of the preferred interference row allows the user pour augmenter conflict preferred to serve indicator of cell range. Moreover, the report broadband RI is generally solid and feedback backhaul delays and channel estimation errors.

V. PERFORMANCE EVALUATIONS

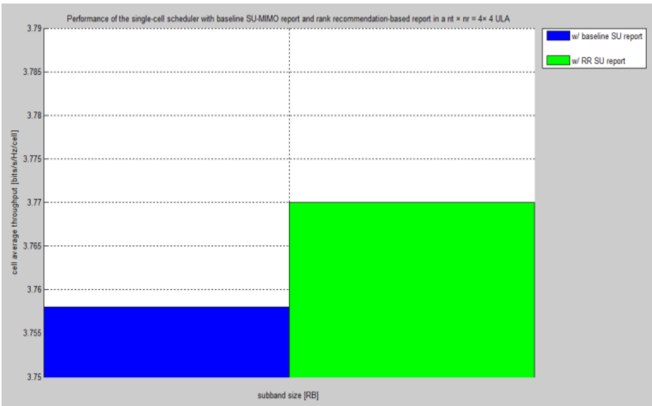
Rank Recommendation When comparing the performance of closed loop SU-MIMO with rank adaptation without coordinating multiple cells (denoted as UB) and the range of master-slave based Coordinated planner (RR as indicated SU) .The simulation Assumptions (aligned with 3GPP LTE -A [2]) are listed in Table I. Suppose one wideband preferred to serve cell range indicator and recommended a single indicator interference range of wideband Reported every 5ms. The value of interference same recommended range for all cells in the CoMP measurement equipment is used to reduce the general feedback and simplify the scheduler. This implies that the range of coordination requires only an additional feedback above 2 bits (to report interference recommended range) compared to the baseline system uncoordinated (SU).

The performance is measured in terms of the average cell spectral efficiency ("cell average throughput") and the 5% cell edge spectral efficiency ("cell-edge throughput").

TABLE I
SYSTEM LEVEL SIMULATION SPECIFICATIONS

Parameter	Specifications
Macro cell layout	2-tier cellular system with wrap-around Hexagonal grid.
Total number of cells	57
Number of clusters	19 clusters Each containing 14 subcarriers Inter site clustering: 3 cells per cluster
Inter site distance	500 m
Carrier frequency	2GHz
Number of transmitting antennas	2
Modulation technique	QPSK
FFT size	1024
Sub-band size	6RB
Rayleigh fading channel specifications	
Bandwidth	500KHz
Number of transmitted bits per frame	1000
Number of symbols per frame	500
Data symbol duration	3.2 μ sec
Cyclic prefix duration	0.4 μ sec
Total duration	4 μ sec
Channel estimation	Ideal and non-ideal minimum mean square error

Figure 2: has double objective: 1) illustrate the sensitivity of the algorithm to a mismatch between their assumptions are transmitted before coding and coordination of the base made by the EU at the time of CSI computing and real decisions Planner 2) illustrate the importance of the combination of the attached indicator cell selection range and preferred service preferred range interference with the programmer Coordinated Master-Slave to harvest cell edge performance enhancements. The dynamic cycle pattern$I_1^{(i)}, I_2^{(i)}, I_1^{(i)}, I_2^{(i)}, I_3^{(i)}$ and MMSE receiver with ideal ICI rejection capability are used. Intuitively, if the postponements user the effects of information based on the recommendation of range feedback then assembled planner was the baseline (uncoordinated) scheduler, performance can be affected as the reported preferred serving cell range $R * q$ can be over-estimated and assumptions about the EU Coordination sent followed by the base stations.



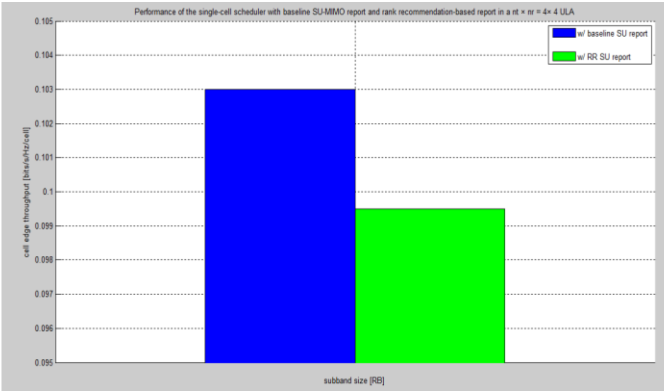
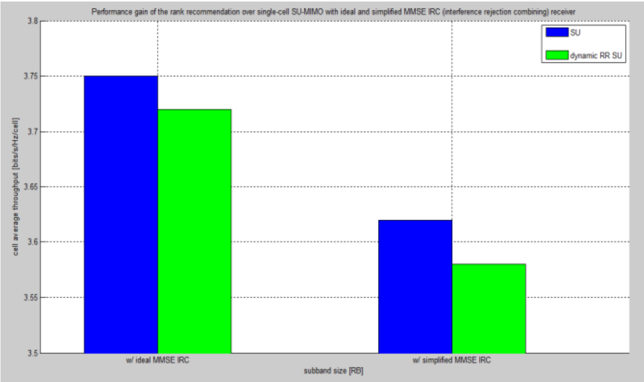


Figure.2: Performance of the single-cell scheduler with baseline SU-MIMO report and rank recommendation-based report in a $n_t \times n_r$ = 4× 4 ULA (4,15).

To assess this impact, we study the performance of a single cell (denoted as reference) scheduler when two different assessments Reported information is: the preferred rank reported serving cell and CQI than those calculated in the reference system and assuming those calculated recommendation rank. As we can see from Figure 2 no gain (or even a slight loss at the edge of the cell) is observed due to the lack of proper coordination.

Figure 3 shows that the coordination system also provides significant gains with other types of receivers, receiver know MMSE ICI with a simplified rejection capability (not rely on the DM-RS of cells measurement interfering).



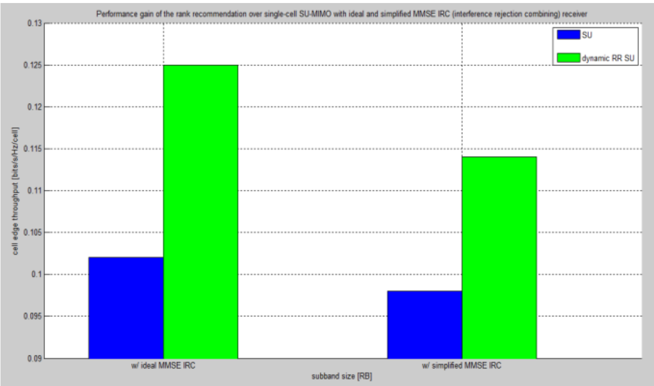


Figure.3: Performance gain of the rank recommendation over single-cell SUMIMO with ideal and simplified MMSE.

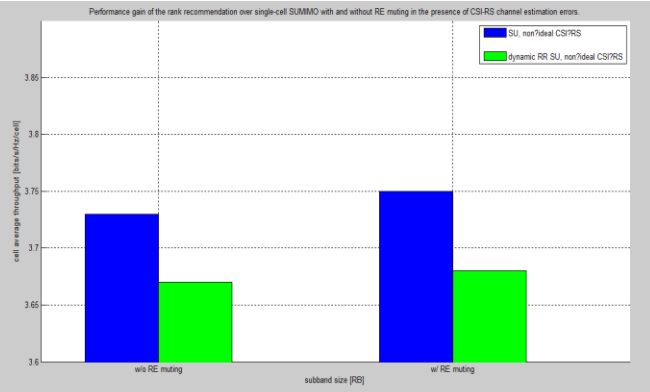
Calculate the receiver filter using an estimate of the covariance matrix of the interference at the pre-coded interference in cells is the identity matrix. A significant increase of approximately 17% at the edge of the cell with the master-slave scheme of planning coordinated range-based recommendation proposal on the baseline (without coordination) system was also observed.

Without rank recommendation	With rank recommendation
Average cell spectral efficiency(cell average throughput)	
• Without multi-cell coordination is 3.74 bits/s/Hz/cell. • With multi-cell coordination is 3.67 bits/s/Hz/cell. ➢ The throughput is achieved by 1.5% without rank recommendation.	• Without multi-cell coordination 3.78 bits/s/Hz/cell. • With multi-cell coordination 3.68 bits/s/Hz/cell. ➢ The throughput is achieved by2% without multi cell coordination.
Cell edge spectral efficiency(cell edge throughput)	
• Without multi-cell coordination is 0.104 bits/s/Hz/user. • With multi-cell coordination 0.108 bits/s/Hz/user. ➢ The throughput is achieved by 21%.	• Without multi-cell coordination 0.102 bits/s/Hz/user. • With multi-cell coordination 0.1208 bits/s/Hz/user.. ➢ Here the throughput is achieved by 17%.

Table2. Throughput achieved by Rank recommendation with ideal MMSE and Simplified MMSE.

From Figure .4 the degree of efficiency of coordination errors in the estimation reference signals used for measuring channel (denoted as CSI-RS for LTE). Channel estimation mean square error as a function of the first wideband SINR level simulator was based link and applied to the system level simulator is calculated.

From Figure 4, we note that the multi-cell coordination is affected by measurement errors CSI-RS, although the recommended rank is a broadband information. Despite this sensitivity, gain of 12.5% on the cell edge is still feasible Compared to a network is not based on multi-cell coordination. To recover the loss from the measurement errors CSI-RS, we perform muted Resources (as standardized LTE-A) in the adjacent cell and evaluate the performance of the rank of coordination in the presence of measurement error ITUC RS.



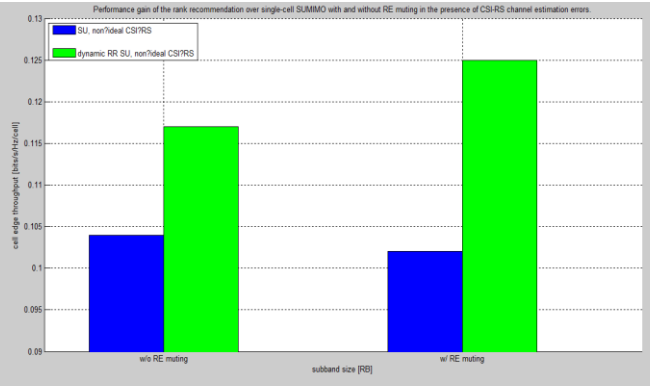


Figure.4: Performance achievable by rank recommendation over single-cell SU-MIMO with ideal and simplified MMSE IRC receiver.

Muted coordination of resources between the cells allows better reception of the CSI-RS of other cells and at the same time measurement accuracy better channel for CSI-RS of the serving cell. With resources mute the rank of coordination is shown to recover most of the gain achieved with perfect channel estimation.

MME-IRC method	Rank recommendation method
Average cell spectral efficiency(cell average throughput)	
• Without multi-cell coordination is 3.75 bits/s/Hz/cell. • With multi-cell coordination 3.73 bits/s/Hz/cell. ➢ The throughput is achieved by1%.	• Without multi-cell coordination 3.635 bits/s/Hz/cell. • With multi-cell coordination 3.58 bits/s/Hz/cell. ➢ The throughput is achieved by1%.
Cell edge spectral efficiency(cell edge throughput)	
• Without multi-cell coordination is 0.1025 bits/s/Hz/user. • With multi-cell coordination 0.125 bits/s/Hz/user. ➢ Throughput achieved by 12.5%.	• Without multi-cell coordination 0.097 bits/s/Hz/user. • With multi-cell coordination 0.0.114 bits/s/Hz/user. ➢ Throughput achieved by 21.5%.

Table .3: Performance of rank recommendation over simplified MMSE-IRC.

Throughput achieved by MMSE-IRC receiver	Throughput achieved by Rank recommendation based coordinated scheduling method
➢ Throughput 12.5%.	➢ Throughput 21.5%
➢ On comparing 9%throughput is achieved by rank recommendation method over MMSE-IRC method.	

Table.4: Comparison Result

On comparing Rank recommendation based coordinated scheduling with simplified MMSE-IRC method the cell edge performance is increased by 9%.

VI CONCLUSION

Introduced here a novel and interference mitigation technique practical basis was the dynamic coordination of transmission is among cells in order to help users benefit cell edge transmissions senior. Coordination requires users report a recommended range for interfering cells. After receiving such information, the interfering cells coordinate with each other informed decisions to assume the transmission lines would be most beneficial for users of the neighboring cells victim and maximize a utility function network. This method is shown to provide cell performance gain last significant generation of uncoordinated LTE-A system under a very limited feedback and backhaul above. It allows efficient link adaptation and is robust to channel measurement errors.

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