International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 7 Issue 02, February-2018

Interference Mitigation Technique for Downlink Cellular Network by Advanced Receiver and Scheduling Mechanism

Hetal A. Chalaliya
PG Student
Department of Electronics and Communication
Dr. S. & S.S. Gandhy Government Engineering College, Surat

Prof. Nita T. Dave
Ass. Professor
Department of Electronics and Communication
Dr. S. & S.S. Gandhy Government Engineering College, Surat

Prof. Sarosh K. Dastoor
Ass. Professor
Department of Electronics and Communication
Sarvajanik college of engineering and technology

Abstract: **Deployment of 5G cellular networks consists of small cells like picocell, Femtocell and Macro cell in dense HETNET scenario. Interference mitigation is one of the parameter to be considered for reliable communication services. There is interference between femto –femto, femto-macro and macro-macro. In this paper, we address the problem of interference in downlink cellular networks where cell edge users may suffer from high interference. Here we describe an approach that mitigates the interference with the use of advanced receiver combined with scheduling mechanism for cell assignment. The duty of joint scheduling mechanism is to determine serving User Equipments (UE) and Channel State Information (CSI) jointly which includes transmission schemes and modulation. Based on this information cell assignment procedure will occur. Joint scheduling mechanism can be implemented using specific scheme. Advanced receiver will use this CSI and suppress or cancel interference experience in downlink cellular network. Improvement in SINR and throughput has been obtained by 5 to 10% using given approach.**

Keywords: Interference, Advanced Receiver, Scheduling Mechanism.

I. INTRODUCTION

Over a last few decades, there is massive increment in the user demand for high data-rates in cellular communication. To meet this demands, effective improvement require in heterogeneous network architecture for mobile communication. The 5G network will use heterogeneous characteristics and capacities like macro cell, pico cell, femto cell, Radio Relay Heads (RRH) etc. In addition to densification of electronic gadgets requires efficient interference alignment and resource usage methods in order to increase the data rates. By deploying large number of small cell in heterogeneous network the capacity will significantly increase. However, deployment of HetNets faces number of challenges amongst which interference management is biggest concern [1].

In [1] author describes different techniques to mitigate interference at the network side as well as at the receiver sides. At network side, joint scheduling mechanism is applied. In which UE are not always served by the strongest perceived cell. The method will useful in load balancing and also improve performance. A Network-Assisted Interference Cancellation and Suppression (NAICS) receiver can be used for interference mitigation at receiver side. In [2] author describes benefits UE side approach while using the network information theory. Network-side interference mitigation needs to be harmonized with receiver side interference mitigation for performance improvement. If joint scheduling elaborated with advance receivers then it will be beneficial in interference management [3]. Distributed resource allocation algorithm which is describes in [4] will first identify impotent users, and then protects that users by assigning resources. Inter-cell interference coordination (ICIC) information is transmitted to neighbouring base stations via the X2 interface [4]. A network upgrade with small cell deployments is simulated in a realistic metropolitan scenario to satisfy the traffic growth forecast over a period of ten years. Simulator is used to model the network behaviour of IRC receiver. The deployment time, scale and cost of the small cells improved by interference mitigation solutions are presented. The simulation results show that small cell deployments are the one of the way to increase the system capacity [6]. In recent standards, interference mitigation technologies, like the linear interference rejection combining (IRC) receiver and Enhanced Inter-Cell Interference Coordination (eICIC), are introduced to address the co-channel interference between macro and small cells in downlink. In mobile network wireless communications, Network side interference significantly reduces using co-ordinated scheduling Thus, for overall performance enhancement coordination among multiple cell require [7].The Resource Allocation Algorithm maximize the throughput of network. Cuckoo search Algorithm is applied for the problem of resource optimization allocating the suitable power and bandwidth. This resource allocation leads to reduction in cross-tier interference small cell networks [8]. The virtual layer based algorithm detect interference situation in the network and based on that information power control and optimization take place which leads to autonomous interference minimization [9].

There is not any interference management strategies were considered in previous LTE standard like release 8 and 9 not even receiver technologies because of an implementation issue. However, It is very beneficial to mitigate interference at the UE-side in co-ordination with the network-side interference management. Here we deal with two aspects for interference mitigation. One is network side with the help of centralised joint scheduling mechanism for cell assignment and other at user equipment (UE) side by use of advanced receiver.

Interference experienced by the users can be reduced by use of centralised scheduling mechanism. It also helps in load balancing in resource usage. To analyse Network side Interference one can use BB pool mechanism [2]. Similarly, for UE side Interference Suppression (IS) and Interference Cancellation (IC) are two advanced receiver that are used. Interfering signals can be detected and cancelled non-linearly using advanced receiver. The interference reduction that advanced receivers can achieve is strongly influenced by the transmission rate, as well as the rank [3].

Rest of the paper is organised as follow: Section II presents proposed technique with centralised scheduling and advanced receiver; Section III describe the network scenario and the signal model; Section IV describes simulation analysis and results; Section V presents the conclusion of paper.

II. DESCRIBED ALGORITHM

A. *Joint scheduling mechanism*

Joint scheduling is used at network-side for interference management in cellular systems, in which the transmission rates and coding schemes of cells in cluster are determined jointly. The transmission schemes of multiple nodes and serving UE are determined by joint scheduling mechanism. Centralised and distributed are two different techniques to implement joint scheduling. In centralized joint scheduling, all the information related to the user or channel is gathered and sent to the central controller; Scheduling decision was send to each node after performing calculations by central controller. But centralized schemes increases burden on backhaul processing communication and increases delay in decision. In case of distributed manner each nodes does its own calculation and exchanges summarized information with the other nodes. The advantage of distributed manner is that sometimes it is iterative and the performance improves with the number of iterations, but simultaneously it suffers delay.

B. *Advanced receiver*

Conventionally receivers assume as a noise-limited operational device. Maximum-Likelihood (ML) and Zero-Forcing (ZF) or Minimum Mean square Error Equalization (MMSE) receiver are some of example which is designed on optimal approach. In reality user always experience interference due to densification of network. The interference is basically a desired signal of neighbouring cell so it is different form noise in its statistical and physical characteristics. Interference signals are nothing but the useful signal of another base station or UE. It means that interference signals similar to the desired signal in terms of modulation scheme and structure of signal. Previously there was no practical way to handle interference and hence it was treated as part of noise. This handling of interference is improper which leads in Performance loss. Proper interference management requires for performance improvement.

Interference Management by an advanced receiver means that the receiver has the capability to take advantage of the structure of the interference signals, including constellation, coding scheme, channel modulation, and resource allocation. Architecture of advanced receiver helps to improve the performance of desired signal decoding. The application of advanced receivers is not useful in inter-cell interference mitigation of the cell edge user but also helps in intra-cell interference. Network Assisted Interference Cancellation and Suppression (NAICS) support this kind of advanced receivers. Interference Suppression (IS) and Interference Cancellation (IC) are two major group of advanced receiver for interference management. Interference can be mitigated linearly without true decoding with the help of IS and IC receivers like Minimum Mean Square Error and Interference Rejection Combining (MMSE & IRC) receiver. These receivers successively detect and cancel the interfering signal in a non-linear way. The interference reduction that advanced receivers can achieve is effected by the transmission rate, as well as the rank, at the serving and interfering cells. This study makes use of two types of advanced receivers, MMSE and IRC.

III. SYSTEM MODEL

A network with C cell and U users is assumed for Joint Cell Assignment and Scheduling Algorithm. U users will provide their Channel State Information to their related cells, which are used by the central control unit to construct a U×C matrix M . Each element of Matrix M is represented as m_{uc}. Here U is number of user, but treated as a constant for computational simplicity. The central control unit assign cell to each user by maximizing the sum of the metrics. Here constraint is that that each cell serves at most one user per Transmission Time Interval (TTI).
Mathematically, It is represented as,

$$\text{Arg max} \sum_{u=1}^{U} \sum_{c=1}^{C} m_{uc} b_{uc} \quad \text{......................................(1)}$$

$$\text{s.t.} \quad \sum_{u=1}^{U} b_{uc} \leq 1, \quad \sum_{c=1}^{C} b_{uc} \leq 1, \quad b_{uc} \in \{0,1\} \quad \text{...(2)}$$

Where, $m_{uc} \geq 0$ is the scheduling metric element and b_{uc} is a binary variable that equals to 1 for cell assignment and 0 otherwise. The cell assignment problem has been solved iteratively by applying following steps [1].

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 7 Issue 02, February-2018

Step-1: search for the largest user metric m_{uc}.
Step-2: set that largest m_{uc} equals to zero.
Step-3: The process is repeated, until all cells are occupied or assigned to users

We can identify which user will serve by which cell. Link adaptation parameters (i.e., modulation and coding scheme, rank, etc.) is being determined by each cell individually for its assigned user, based on the most recently received CSI report.

In this section, we describe advanced Minimum Mean-Square Error (MMSE) and Interference Rejection Combiner (IRC) receivers. For downlink network received signal can be expressed as

$$X=H_0S_0 + \sum_{q=1}^{q=q-1} H_qS_q + N \quad ....(3)$$

Here S_0 is desired signal which is sent to the UE and H_0 is propagation channel. S_q and H_q (q = 1, 2, …, q - 1) are q interfering signals and their corresponding channels and N is an additive white noise vector.

1) *MMSE Receiver:* The MMSE receiver considers interference as a noise vector. The channel matrix for the desired signal, only interference-plus-noise power must be estimated by the MMSE receiver. The MMSE receiver can be expressed as

$$\hat{S}_0=W_{MMSE}\, X ....(4)$$

The weight matrix of MMSE can be defined as follow:

$$W_{MMSE}=H_0^H (H_0H_0^H + (\sigma_I^2 + \sigma_N^2)I)^{-1} ....(5)$$

Where, σ_I^2 is interference power of other cells, and σ_N^2 is the noise power. Receiver already has knowledge about Cell Specific Reference Signal (CRS), so the interference and noise power can be estimated as

$$\sigma_I^2 + \sigma_N^2 = x(k,l) - H_0(k,l)r(k,l) ....(6)$$

Here, r(k,l) is the CRS sequence of the serving cell. The output SINR of MMSE receiver is calculated as,

$$SINR_{OUT}\ \frac{P_0W_{MMSE}H_0H_0^HW_{MMSE}^H}{W_{MMSE}(R_{ICI}+\sigma_N^2\ I)W_{MMSE}^H} ....(7)$$

Where, P_0 represent the tx power of the interfering cell.
The covariance matrix of ICI is represented by

$$R_{ICI} = \sum_c^{C-1} P_cH_cH_c^H ....(8)$$

Where, P_c is the transmission power of the interfering cell

2) *IRC Receiver:* The IRC receiver is more efficient then MMSE receiver in strong interference scenarios. The IRC receiver can be expressed as

$$\hat{S}=W_{IRC}\, X ....(9)$$

The IRC weight matrix is obtained by

$$W_{IRC} = H_0^H (H_0H_0^H + R_{I+N})^{-1} ....(10)$$

Where, $R_{(I+N)}$ is the interference and noise covariance matrix. Because the CRS sequence of the serving cell is known at the receiver, the interference and noise covariance matrix can be estimated as

$$R_{I+N} = E[\tilde{X}(k,l)\tilde{x}^H(k,l)] ....(11)$$

Where $\tilde{x}$ (k, l) expressed as

$$\tilde{x}(k,l) = x(k,l) - H_0(k,l)r(k,l) ....(12)$$

The output SINR of IRC is calculated as

$$SINR_{OUT} = \frac{P_0W_{MMSE}H_0H_0^HW_{MMSE}^H}{W_{MMSE}(R_{ICI}+\sigma_N^2\ I)W_{MMSE}^H} ....(13)$$

Where, the covariance matrix of ICI is expressed as in MMSE.

IV. SIMULATION METHODOLOGY AND RESULTS

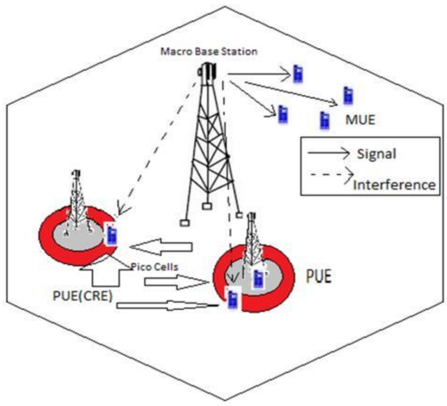

Fig 1: Network model for interference mitigation

The described method is evaluated for a 2-tier heterogeneous network. The sectors of three adjacent macro-cells have been considered. A hexagonal 3-sector side grid has base stations which are separated by the inter-site-distance (ISD). An outdoor picocell is placed close to the cell-edge of one of the macro eNodeBs at a distance equal to 0.8*cell radius(R) to serve as a hotspot. The three adjacent sectors from different cell sites and the picocell determine the coordination zone. These adjacent sectors are spaced close to each other, and therefore, high interference can be expected. Interference from other neighbouring stations is significantly smaller, yet not negligible. Thus, the basic macro eNodeB block is surrounded by nine additional base stations which build an interference belt around the considered area. These stations cause uncontrollable interference to the users within the coordination zone. This interference is treated as noise. Users are uniformly distributed over the coordination zone. Inside the picocell, additional users are distributed to account for the fact that it serves as a hotspot. In both cases, the number of users depends on the load. Users arrive according to a Poisson process and have deterministic service time.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 7 Issue 02, February-2018

Table 1: Simulation Parameters of system model

Sr. No	Parameter	Value
1	Cell structure	Hexagonal grid, 2-tier, 19 cell sites, 3 sectors per site
2	Type of Network	Heterogeneous network
3	No. of UEs per sector	50 UEs
4	Antenna configuration	BS: 4, MS: 4
5	Channel model	WINNER channel models
6	User distribution	Poisson process
7	Doppler velocity	300 Hz
8	UE max TX power	23 dBm
9	Center frequency	2.6 GHz
10	Bandwidth (no. of RBs)	20 MHz (100 RBs)
11	Channel estimation	Ideal
12	Scheduling	Joint scheduling
13	Traffic model	Full buffer
14	BS antenna gain plus cable	loss 14 dBi for micro, macro cell case
15	Path loss model	PL = 130.5 + 37.6log10 (R)
16	Shadow std. deviation	10 dB
17	Penetration loss	20 dB
18	MS noise level	174 dBm/Hz
19	UE noise figure	9 dB
20	Correlation distance of shadowing	50 m
21	Minimum distance between UE and cell C	35 m
22	Advanced receiver Conventional receiver	MMSE, IRC

Table 1 summarizes simulation parameters with its values and table 2 summarizes Interpretation of symbols. Figure 2 shows cell assignment of user achieved by joint scheduling mechanism. Fig 3 and fig 4 presents the 5th and 50th percentile throughputs as separate line for distributed and centralised cases. The described centralised solution provides significant gains for data-rates between 13% and 63%. The Interference cancellation efficiency values that the NAICS receiver achieves are presented in fig 6. From graph we can see that value of IC efficiency is increased with offered load, similarly for DI-SINR in fig 5. We can see how the Low observed SINR values Match with fig 6 results.

TABLE 2: SYMBOLS AND THEIR INTERPRETATION

Sr. No	Symbol	Interpretation
1	U	No. of users
2	C	No. of cell
3	M	U×C Matrix
4	m_{uc}	Element of M
5	X	Received signal
6	$\hat{S}$	Receiver Matrix
7	S_0	Desired signal to UE
8	H_0	Propagation channel
9	q	Interfering Signal
10	N	White noise vector
11	W_{MMSE}	Weight matrix of MMSE receiver
12	W_{IRC}	Weight matrix of IRC receiver
13	P_0	Transmission receiver
14	σ_I	Interference power of other cell
15	σ_N	Noise power
16	r(k, l)	Cell Reference Signal
17	$\tilde{x}$	Modified received signal

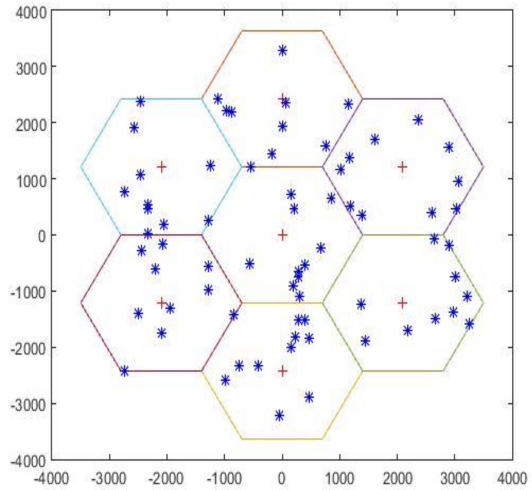

Fig 2: Cell assignment of user by joint scheduling mechanism

Table 3: Average throughput and spectral efficiency of different receiver

Advanced receiver	UE throughput (Mbps/user)	Average UE spectral efficiency (bps/Hz/user)
MMSE	1.159	0.071
IRC	1.209	0.073
ML	4.299	0.172
SIC	3.105	0.124

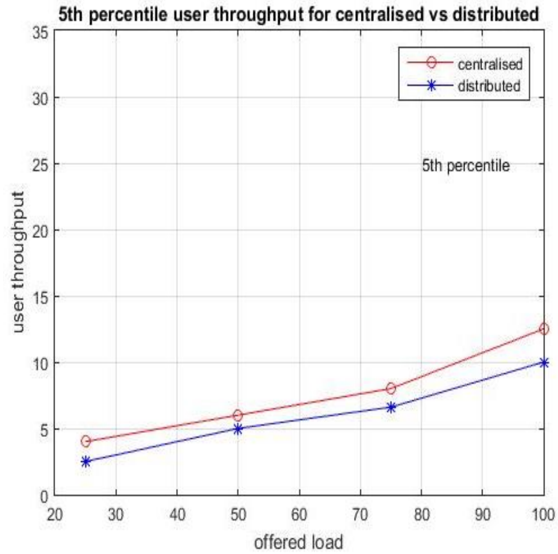

Fig 3:5th percentile of user throughput for distributed and centralised scheduling with IRC receiver.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 7 Issue 02, February-2018

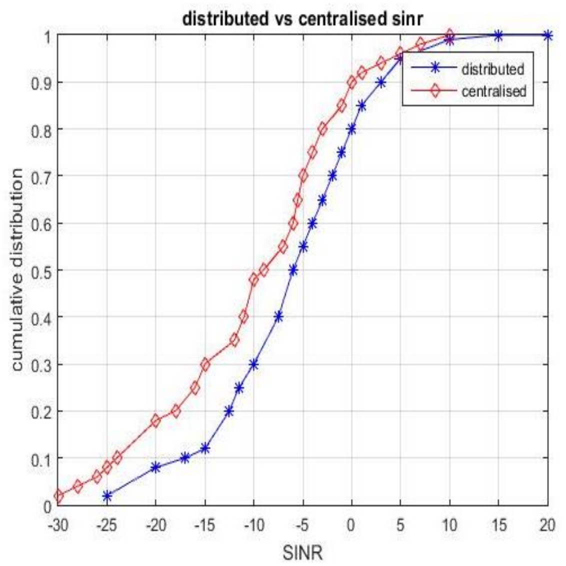

Fig 5: Dominant Interference SINR for centralised and distributed scheduling algorithm with NAICS receiver

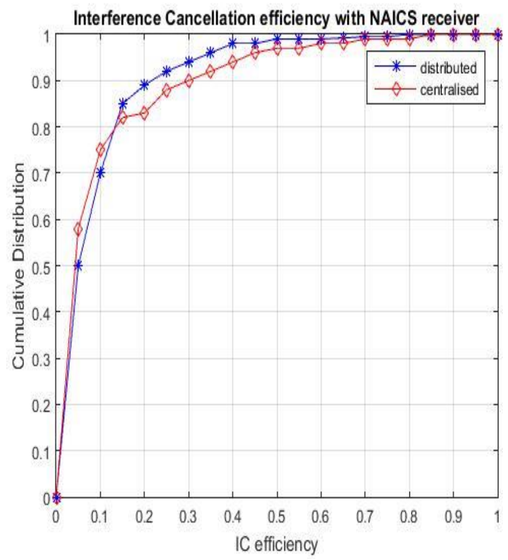

Fig 6: Interference Cancellation efficiency for centralised and distributed scheduling algorithm with NAICS receiver.

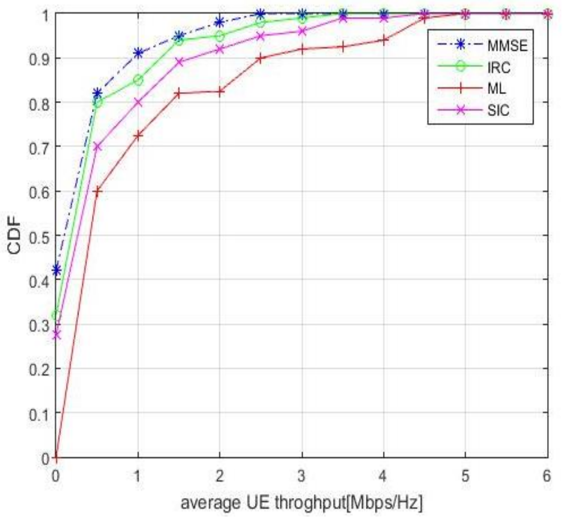

Fig 7: Average UE throughput for different types of receiver.

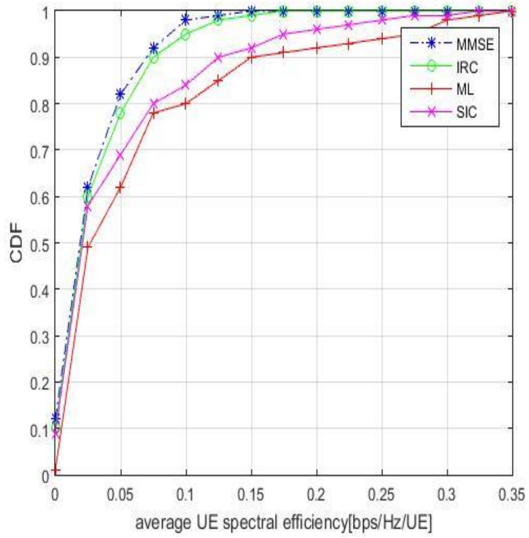

Fig 8: Average UE spectral efficiency for different types of receiver

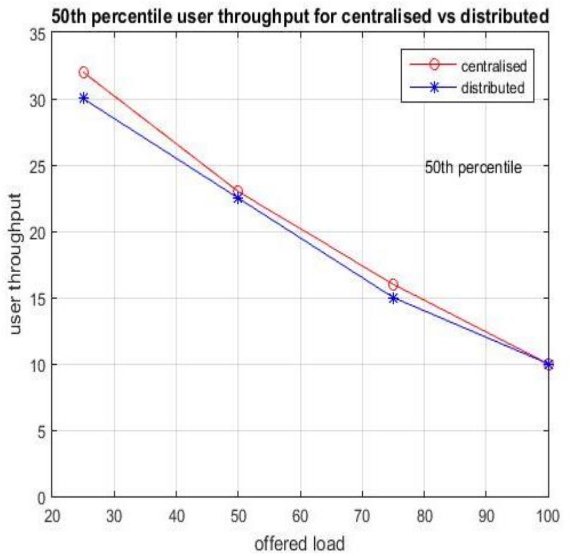

Fig 4 :50th percentile of user throughput for distributed and centralised scheduling with IRC receiver

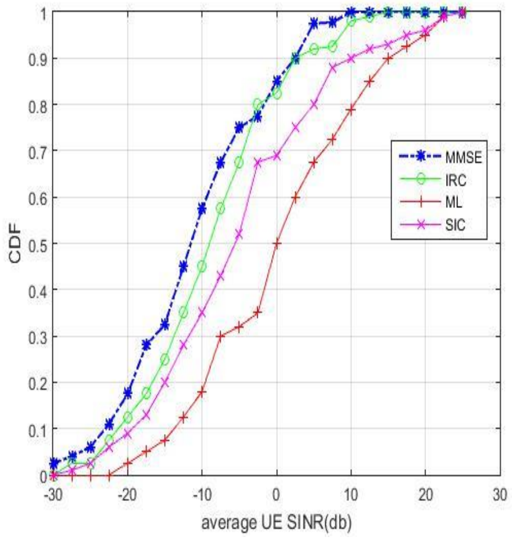

Fig 9: Average UE SINR for different types of receiver.

Figure 9 shows that average UE SINR for MMSE, IRC, ML and SIC receivers. We observe that MMSE and IRC receiver increases the SINR value compare to other conventional receivers. Whereas figure 7 and figure 8 show improvement in the performance of receiver in the form of throughput and spectral efficiency. Table 3 summarise the performance of receivers in terms of SINR, throughput and spectral efficiency.

V. CONCLUSION

In this paper, we analysed technique to suppress and cancel interference from neighbouring cells at the network and UE side. Advance receiver take advantage of interfering signal structure as they are desire signal for other cell and can successfully detect, decode and suppress or cancel the signal. MMSE and IRC receivers are used to suppress and cancels the interference, not only suppress and cancel interference but also improve capacity of network and data rates. From graph we can say that IRC receiver have better performance than MMSE. The simulation results show that the advanced receiver achieves higher SINR (10%-15%), throughput (4%-10%), and spectral efficiency than those of conventional receivers.

REFERENCES

[1] "Improving Dense Network Performance through Centralized Scheduling and Interference Coordination".Victor Fernandez-Lopez, Klaus I. Pedersen, Beatriz Soret, Jens Steiner, Preben Mogensen. IEEE Transactions on Vehicular Technology (Volume: 66, Issue: 5, May 2017)DOI: 10.1109/TVT.2016.2609239

[2] 3rd Generation Partnership Project,Technical Specification Group Radio Access Network; Study on Network-Assisted Interference Cancellation and Suppression (NAICS) for LTE.

[3] "Advanced Interference Management for 5G Cellular Networks".Wooseok Nam, Dongwoon Bai, Jungwon Lee, and Inyup Kang. IEEE Communications Magazine (Volume: 52, Issue: 5, May 2014)DOI:10.1109/MCOM.2014.6815893

[4] "Interference Coordination-based Downlink Scheduling for Heterogeneous LTE-A Networks". Rico Mendrzik, Rodrigo A. Justavino Castillo, Gerhard Bauch, Eiko Seidel. Wireless Communications and Networking Conference (WCNC), 2016 IEEE.DOI: 10.1109/WCNC.2016.7564879.

[5] "Advanced Inter-cell Interference Management Technologies in 5G Wireless Heterogeneous Networks (HetNets)
Farah Raisa, Asif Reza, Khaizuran Abdullah" Research and Development (SCOReD), 2016 IEEE Student Conference.DOI: 10.1109/SCORED.2016.7810036

[6] "Network Upgrade with LTE-Advanced Small Cells".Zhuyan Zhao,Hao Guan,Jeroen Wigard,SangMin Lee,Dae Hee Kim,Kyung Min Hwang.Vehicular Technology Conference (VTC Fall), 2015 IEEE.DOI: 10.1109/VTCFall.2015.7391034

[7] "Rate and UE Selection Algorithms for Interference-Aware Receivers". Vitaly Abdrashitov, Wooseok Nam, Dongwoon Bai. Vehicular Technology Conference (VTC Spring), 2014 IEEE 79th. \DOI: 10.1109/VTCSpring.2014.7023067

[8] "A Femtocell Cross-Tier Interference Mitigation Technique in OFDMA-LTE System: A Cuckoo Search based Approach" Motea Al-omari, Abd Rahman Ramli, A. Sali and Raja Syamsul Azmi. DOI: 10.17485/ijst/2016/v9i2/80490

[9] "Autonomous algorithms for centralized and distributed interference coordination: a virtual layer-based approach
Martin Kasparick1and Gerhard Wunder.EURASIP Journal on Wireless Communications and Networking
December 2014.DOI: 10.1186/1687-1499-2014-120

[10] "Performance of Advanced Receiver Employing Interference Rejection Combining to Suppress Inter-cell Interference in LTE-Advanced Downlink".Yusuke Ohwatari, Nobuhiko Miki, Takahiro Asai, Tetsushi Abe and Hidekazu Taoka.

[11] "Advanced Receiver for Interference Suppression and Cancellation in Sidelink System of LTE-Advanced".
Sangmi Moon, Hun Choe, Myeonghun Chu,Cheolwoo You, Huaping Liu, Jeong-Ho Kim,Jihyung Kim, Dae Jin Kim, Intae Hwang.DOI 10.1007/s11277-017-4082-x.