

Inter-Cell Interference Coordination Scheme Based on CoMP

Xiao Xue^a, Ji-hong Zhao^{ab}, Hua Qu^b

^a Department of Communications Engineering, Xi'an University of Posts and Telecommunications, China

^b School of Electronic Information, Xi'an Jiaotong University, China

xuexiao19@gmail.com, eeleeg@gmail.com, qh@mail.xjtu.edu.cn

Abstract—This paper presents an ICIC scheme for LTE-Advanced system, which injects the new technique of LTE-Advanced system called CoMP. The proposed scheme effectively combines the benefits of both frequency reuse and CoMP, which makes system actively handover between the two ICIC schemes through dynamic threshold mechanism. It's shown that the proposed scheme could effectively improve the throughput of the whole network as well as users on edge of cells.

Keywords— LTE-Advanced, CoMP, ICIC, Dynamic Threshold Mechanism, switches the two schemes

I. INTRODUCTION

LTE-Advanced system is based on OFDM technique, which results from the orthogonality of different carriers, the interferences doesn't exist among subscribers occupying different resource blocks in the same cell. However, the carrier resource between cells is reused in frequency, once the same frequency resource is reused between neighbor cells, it may result in serious Inter-cell interference (ICI). The ICI problem is very significant and difficult to solve in LTE-Advanced system. [1]

The main idea of Inter Cell Interference Coordination (ICIC) is to control the interferences between cells through the management of radio resource, which is a kind of radio resource management scheme considering the situation of resource use and load between cells.

At present, in order to meet the higher data rate and higher spectral efficiency requirements for LTE-Advanced system of 3GPP, Inter-Cell Interference Coordination (ICIC) must make some new adjustments to frequency utilization and cell edge data rates, which is required as follows: Researches should consider that Rel8/9 system is backward compatible with R8/9

terminals and minimize the impacts on air interface of physical layer. Consider that how to introduce new LTE-Advanced techniques in further study (e.g. CoMP).

In OFDM system there are already some interference coordination schemes based on frequency multiplexing technique. [2] We proposed a new kind of active interference coordination scheme on the basis of CoMP(Coordinated Multi-point Transmission) in this draft. The system switches the two schemes automatically through dynamic threshold mechanism. This scheme can effectively improve the throughput of whole network and cell edge users.

II. ICIC SCHEME BASED ON CoMP

CoMP based active interference coordination scheme introduced new technique CoMP to solve the interference problem. It selects the cooperation among three fixed cells to study, as is shown in figure 1, where three base stations as a group conduct the coordinated multiple points communication. [3]

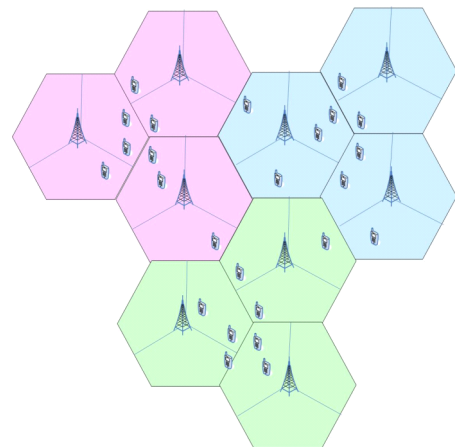


Figure 1. System Architecture

System initialized eNodeB sends reference signals RS to UEs in the cell, then the UE receiving the RS will submit a report including CQI、SINR、RSRP, etc. [4] After receiving

these information, a eNodeB firstly determines the UE identity, dividing UEs of the cell into cell centre UE (CCU) and cell edge UE (CEU). [5] For a CCU, its interference from adjacent cells is very small, thus it can use all bands to allocate resources according to certain scheduling rules. As to a CEU, because of interference from adjacent eNodeB, so this scheme employs an idea of interference coordination handover.

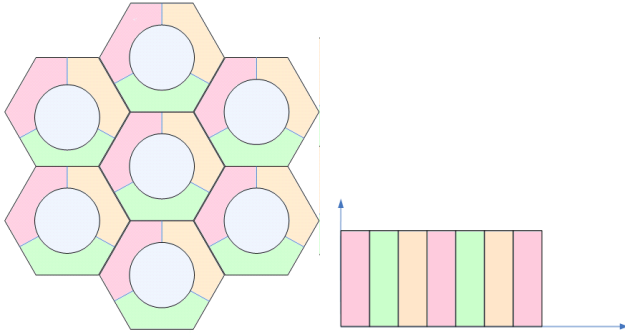


Figure 2. Improved Frequency Multiplexing Scheme

When the cell load is low or medium, using improved frequency multiplexing scheme to resolve the inter-cell interference of LTE-A system is illustrated in fig.2. It fully utilizes the advantages of this way like less signaling interactions and simple realization to avoid the coordination overhead from CoMP technique. Concretely, a cell is divided into three sectors that use different frequency bands respectively while the same location in each cell uses the same band, thus the edges of adjacent cells can use different frequencies to avoid interference. During frequency bands partitioning, instead of dividing by whole segments, using distributed bands partitioning also guarantees different frequencies for adjacent cells.

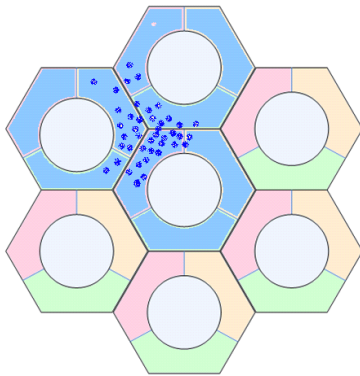


Figure 3. Joint Transmission Scheme

If a sector load is high in the target cell, trigger the dynamic threshold mechanism and start the joint transmission scheme. [6] For example, fig.3 uses CoMP to solve interference issues with joint transmission between three adjacent eNodeBs. In the cells without high load, frequency multiplexing scheme is still in use.

III. DYNAMIC THRESHOLD MECHANISM

Since the scheme adopts handling of high and low load case, a good handover method is important. We use a dynamic threshold mechanism here as fig.4 shows to achieve an elastic handover. This mechanism mentioned above can also be used to determine UE's location. Dynamic threshold mechanism is mainly divided into three steps: (1) Determine the double-threshold value (2) Initialize the information needed to compare (3) Measure the information of updated status.

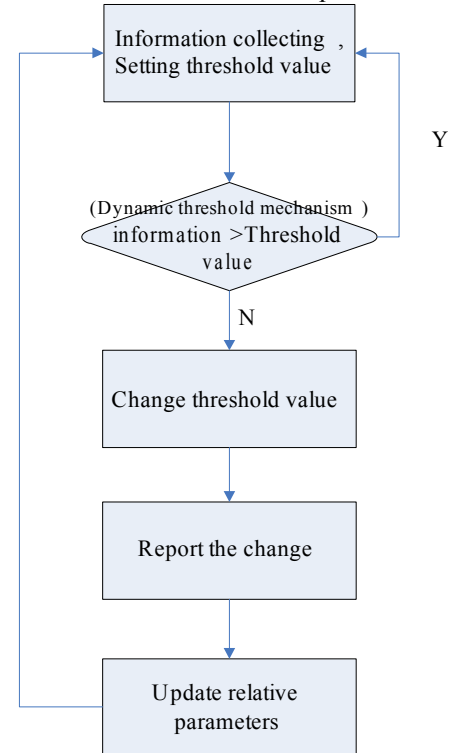


Figure 4. Flow Chart of Dynamic Threshold Mechanism

The specific steps of dynamic threshold mechanism application in determining UE location information is:

1) *Signaling transmit Double-threshold value*

Base station firstly inform users the double-threshold (TH1 and TH2) through upper RRC signaling. The double-threshold value can be determined according to system status such as load, internal / edge user ratio, etc. $TH1 < TH2$.

2) *Initialize of RSRP status information*

User compares received threshold information with TH2 according to measured RSRP value. If TH2 is smaller than the threshold, which means the user is located in the cell edge, UE should report corresponding RSRP information and inform the base station its location status. Otherwise, it means that the UE is within the cell and sends no information.

3) *Measure and update RSRP status information*

If the UE is within the cell inside, the follow-up measured RSRP value needs to be compared with TH1. The value smaller than TH1 indicates that the UE has moved to the cell edge and should send RSRP information to inform the base station that its location has become edge UE, with the threshold for comparison turning into TH2. Otherwise, no signaling is sent and the measurement is continued. If the UE is in the cell edge, the follow-up measured RSRP value needs

to be compared with TH2. The value larger than TH2 indicates that the UE has moved to the cell inside and should send RSRP information, with the threshold for comparison turning into TH1. Otherwise, no signaling is sent and the measurement is continued.

IV. ACQUISITIONS AND PROCESSING OF LOAD INFORMATION

In the scheme, we introduced the idea of cross-layer optimization which is embodied in the acquisition and processing of upper load information. Load information can be acquired by direct inter-layer communication. With the algorithms or formulas used to calculate the load level, each needed parameter is obtained by searching in all layers and then we can determine the load conditions of current cell. To get the load level of target cell, here we integrated three introduced information which are respectively PRB utilization, load level of adjacent cell and service conditions of current cell.

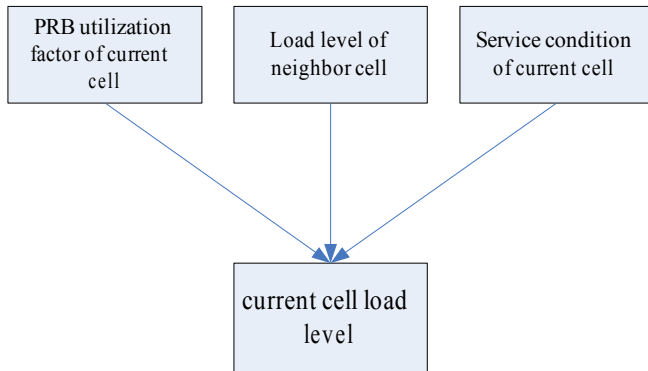


Figure 5. Calculation of Cell Load Level

The PRB utilization factor of current cell is an important measurement for load conditions, it means the active PRB percentage

$$U_{PRB} = \frac{N_{UE} * CBR}{C}$$

where N_{UE} indicates the UE number of current cell, CBR indicates the fixed bit rate of 512 kbps and C indicates the expected cell capacity.

The load level of adjacent cell is the load information exchanged by base stations in collaborative group with X2 interface which can indicate target cell the base station information in collaborative group. HII、OI and RNTP parameters are important and can be obtained from RRC layer. [7]

TABLE 1. LOAD LEVEL OF ADJACENT CELL

	Reported LF value
Two base stations in the collaborative group shows high load	0.5
One base stations in the collaborative group shows high load	0.2

Different from of 1st/2nd generation communication systems that only possess relative single service type which is mainly voice service and don't have to differentiate service types, LTE-Advanced system may provide various services and support many different types of service. It will change the cell load level when data service is large, thus the service condition of current cell is an important parameter for determining target cell load level. The information is obtained from MAC layer.

TABLE 2. SERVICE CONDITION OF CURRENT CELL

	Queue length	Reported S value
Non-GBR service		
GBR service	Current length > 80% of buffer length	0.5

Integrating the above mentioned three points, we get the calculation formula of current cell load level:

$$LF = U_{PRB} + \sum S + \sum LF_{CoMP}$$

.

V. CONCLUSIONS

As a new technique introduced in LTE-A, CoMP essentially solved the problem of inter-cell interference. However, because of CoMP's own characteristics and LTE-A system's characteristics, not in all cases the interference coordination scheme by CoMP technique is better than non-CoMP system. In the scenario where the channels are not symmetrical and UE feedback design is uncertain, simply using CoMP to solve interference issue may cause the system performance gain offset by the system overhead.

For this reason, in order to avoid the system overhead brought by CoMP in low load condition, this scheme proposed CoMP technique based active interference coordination which has many advantages including less signaling interactions and simple realization, no interference level increasing in high load, guaranteeing synchronization when UE consolidates coordinated data information and being backward compatible with R8、R9 system.

ACKNOWLEDGMENT

This work is supported by the National Natural Science Foundation of China (no.61071126、60872058) and New Generation Radio Major Projects (no.2010ZX03、2011ZX03)

REFERENCES

- [1] 3GPP TS 36.300 V10.0.0. Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestrial Radio Access Network (E-UTRAN) ,Overall Description,3rd Generation Partnership Project Technical Specification Group Radio Access Network. S.(2010)
- [2] Sanjay Kumar,G Monghal,Jaume Nin,Ivan Ordas,Autonomous : Inter Cell Interference Avoidance under Fractional Load for Downlink Long Term Evolution. J.IEEE (2009)
- [3] .Qi xing wang, Da jie Jiang ,Guang yi Liu,Zhigang Yan.: Coordinated Multiple Point Transmission for LTE-Advanced Systems. J. IEEE(2009)
- [4] 3GPP.R1-080884.Additional RSRP reporting trigger for ICIC.S.(2008)
- [5] 3GPP.R1-081395.Consideration on identification of interior users / exterior users for ICIC.S(2008)
- [6] 3GPP.R1-094279.Extended ICIC-A Rel-10 CoMP Scheme.S.(2009)
- [7] 3GPP.TS 36.331 V9.4.0. 3rd Generation Partnership Project; Technical Specification Group Radio Access Network;Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Resource Control (RRC); Protocol specification .(2010)