REVIEW ON COORDINATED MULTI POINT TRANSMISSION IN CLUSTERING MODEL

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Abstract: Coordinated Multipoint is used to deliver improved work, especially at cell edges by using the facility of more than one base station to setup the communications. LTE (Long Term Evolution) COMP uses a number of various methods dynamically to coordinate the transmission. LTE-A is one of the major aspect and also upcoming concept for interference mitigation in 5th generation (5G). The proposal work is to enhance overall quality for the user and also improving the uses of the network. Cellular networks data traffic will extend at a Compound Annual Growth Rate (CAGR) of 46 percentage from 2017 to 2022, reaching 77.5 Exabyte's per month by2022.wireless networks will need to create number of small cells for this increasing demand. Deployment of small cells will need advanced mitigation techniques to enhance efficiency of spectrum and develop much needed capacity. Coordinated multipoint transmission is used for inter-cell interference (ICI), enhance edge cell throughput and also extending network coverage. However, cooperation will need to be limited cells only due to additional overhead by COMP due to channel state information (CSI) scheduling complexity and other backhaul limitation.

Key terms: coordination multipoint, LTE-Advanced 5, intercell interference (ICI), Channel state information, Backhaul limitation.

I.INTRODUCTION

Wireless cellular networks will be under pressure with the increasing level of data with high bandwidth applications. The overall wireless mobile communication system field is growing very speed. The work of the EARTH project is to address the global environmental challenge by finding effective strategy to substantially reduce energy wastage and to improve energy efficiency of mobile network systems[2].Mobile networks become very trend with high band efficiency due to applications like video streaming, multimedia file sharing techniques becomes more attractive. Cell Densification, Increased Efficiency and Additional Spectrum techniques are initiated to overcome the challenge for 5G.To achieve high spectral efficiency, MIMO(multiple-input multiple-output) is very useful for inter cell interference. Coordination multipoint (COMP) is the major key feature for wireless cellular networks. Many users can join in base stations which are in coordination. To reduce collisions in data transmission, access of base station in coordination approach is initiated by (3GPP) the Third Generation Partnership project in LTE-A[7].This type of method is known as coordinated multipoint(COMP).LTE utilises Orthogonal Frequency Division Multiple Access (OFDMA) as its radio access technology and also with some kind of advanced antenna technologies. The lack of bandwidth, spectrum and power in wireless cellular systems has driven the need for spectrally effective wireless communication systems. In a cellular communication system such as Long Term Evolution (LTE), the Inter-Cell Interference (ICI) is one of the main factors that influences the data rates of the users at the cell-edge and affects the average spectral efficiency of the cell. In wireless mobile system, the BS is located in the cell centre and it only works the customers in its coverage area. The demand of increasing level of data transmission is a major concern that needs to be addressed in relation to cellular wireless networks. In 2016, there was an increasing level in data traffic of 63 percentages, with levels up 18-fold over five years [1]. The demand of increasing level of data must be solved through increased cellular network performance. An increased number of base stations (BS) and spatial reuse are precedent of solutions capable of solving this major problem. However, these kinds of solutions must be accompanied by methods that avoid data transmission collisions, especially in edge cell regions. Coordination among base stations is needed in such cases.

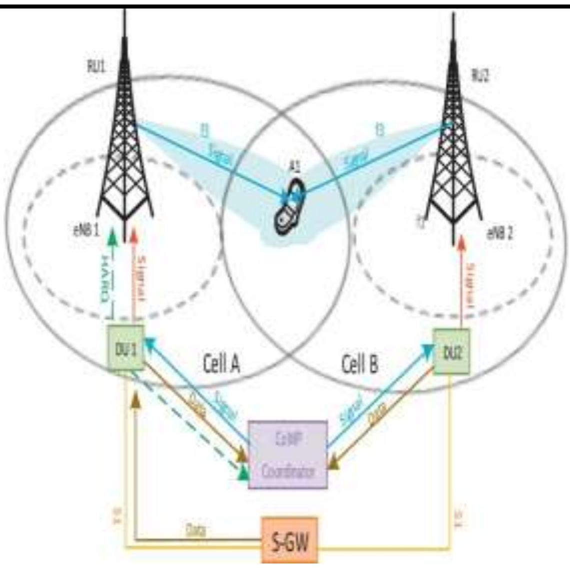

Figure 1: Coordinated multipoint Transmission

In order to preclude data transmission collisions issue, the base station coordination approach has been initiated by the Third Generation Partnership Project (3GPP),in Long Term Evolution Advanced (LTE-A). This kind of approach known as Coordinated Multipoint (COMP). COMP has become one of the key factor in the fifth-generation (5G) wireless communication network. COMP is a network cooperative method that reduce inter-cell interference (ICI) from near cells to give higher spectral efficiency. COMP provides advantages in many directions, such as expanding cell coverage area and improving edge cell throughput method.

II.TYPES OF COMP

The performance of coordination between BSs can be achieved on the Uplink (UL) and Downlink (DL). When there is coordination in the UL, this is referred to as COMP reception or Joint Detection. The received UL signal at multiple BSs may be united using some technical methods such as Maximum Ratio Combining (MRC), etc. This is recognized to be implementation dependent with no impact on the radio interface method. When there is coordination in the DL, this is referred to as Coordinated Multipoint transmission or Joint Transmission. In MU-MIMO, the DL and the UL correspond to the Broad Cast (BC) and Multiple Access Channel (MAC), respectively. The Coordination multipoint transmission method can be compared to the MU-MIMO BC. In this paper, the focus is on COMP transmission and henceforth, any reference to COMP refers to the DL transmission.

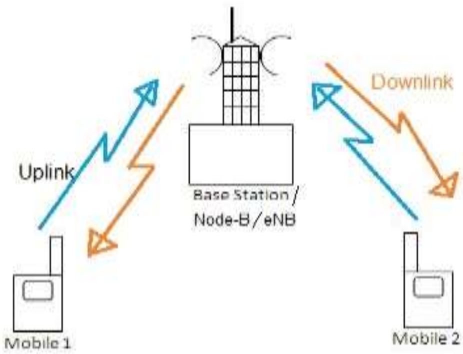

Figure 2: Uplink and Downlink COMP

In the downlink the coordination multipoint schemes are divided into: a) Dynamic scheduling achieved through coordination between multiple cells (is an extension of ICI coordination in LTE Release 8).It refers to this as Coordinated Scheduling or Coordinated Beam forming where the data to a Mobile Station (MS) is transmitted from one of the BSs and as the name suggests the scheduling decisions are coordinated. Due to this issue, only the achieved beams and scheduling determinations need to be coordinated. The user data only needs to be start at one working BS, unlike Joint transmission, discussed next. b) Joint transmission and reception among numerous cells. It refers to this as Joint Processing/Transmission where a single MS receives its data from various BSs. Thus, enhancing the received signal power and cancelling interference. Coherent joint processing puts tremendous needs on backhaul, as the user data needs to be attend at all the coordinating BSs.

2.1 Uplink COMP

Uplink Interference Prediction: The basic idea of UL interference prediction is to perform link adaptation based on predicted signal-to-interference-plus-noise ratio (SINR) values that are likely to occur during the associated data transmissions. Prediction is permitted by exchange of resource allocation information within a cluster of cooperating coordination cells. In addition, the UL receivers provide channel state information related not only to their associated terminals, but also to the strongest terminals of near cells. Due to interference prediction, more appropriate link adaptation can be realized, and hence the performance can be improved. The exchange of resource allocation information between two cells causes only moderate backhaul traffic in the range of 8 Mb/s. Whereas performance gains with intrasite cooperation prove to be rather low, we observe up to 25 percentages gain in spectral efficiency and 29 percentages gain with respect to baseline cell edge throughput if intersite cooperation including up to six interfering cells is simulated. The prediction accuracy degrades if the channel state information gets out dated. Therefore, the X2 latency should not exceed 1 MS, even at low terminal speed.

Uplink Joint Detection: Uplink joint detection states that signals received at various sectors are jointly performed. Hence, virtual MIMO antenna arrays may spread out over various users as well as various base station regions at the network side. Most of the information exchange between cooperating cells is caused by providing the quantized baseband samples received in each and every cell. Channel state information and resource allocation tables are shared in the cooperation cluster as well. First estimates reveal that even with consideration of less than half the cooperation cluster size as described above for interference prediction, the cell-to-cell X2 traffic would exceed 300 Mb/s for10 MHz system bandwidth. This high amount of backhaul traffic motivates the investigation of intrasite joint detection. In case of intersite joint detection including up to three sectors per terminal, gains in spectral efficiency and cell edge throughput account for 35 and 52 percentages, respectively. Sticking with intra-site joint detection, the improvements drop only moderately to 25 percentages on average and 24 percentages at the cell edge. Combining high throughput and low latency as required by joint detection will cause a cost burden for the backhaul, specifically the X2 interface. Therefore, a combination of intrasitejoint detection (no X2 needed) and intersite interference predictions (low throughput demand) has been considered.

2.2 Downlink COMP

This system can be classified into two types: joint processing coordinated multipoint (JP-COMP) and coordinated beam forming coordinated multipoint (CB-COMP) [10]. The main difference between JP-COMP and CB-COMP lies in their implementation scheme, i.e., whether user information is sends across the cooperating cells through backhaul or not [13]. JP-COMP exchanges data and CSI concurrently among cooperating base stations in a cluster, while CB-COMP only shares CSI without exchanges of data among cooperating base stations in a cluster. In the COMP schemes, the formation of informative clusters is a critical aspect affecting overall COMP process. However, detecting the optimal clustering approach typically needs combinatorial optimization due to the nonlinearity. Normally, suboptimal clustering results in maximised computational complexity, failures of correct data exchanges, and minimum optimal throughput performances of COMP. A limited backhaul capacity is another major aspect that reduces JP-COMP performance levels on the real-world networks. Clustering of cells in COMP has been widely studied in recent years as part of effort to enhance inter-cell interference management.

III. CLUSTERING ALGORITHMS

Clustering algorithms are derived into two methods: the static and dynamic clustering methods. Static clustering methods have been planned in order to optimize edge throughput cells by relying on a predetermined fixed base station cluster. Each and every static clustering algorithm utilizes different strategies to predict the efficient cluster formation. Examples include overlapping, formation cooperative strategies, and sectoring. These clustering methods have simple configurations. While we compare to dynamic COMP clustering is more complex with increased signalling overhead but it’s more responsive to the changes in the network.

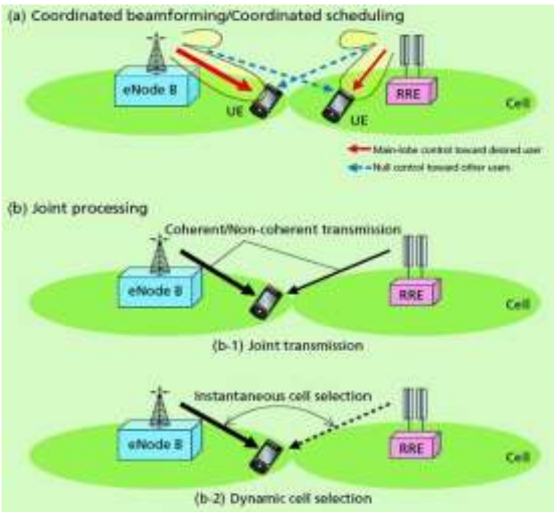

Figure 3.a) coordinated beam forming b) joint processing

IV. CLUSTERING IN PRACTICAL COMP NETWORKS

We applied different optimization criteria in the ideal model where the system is more flexible to accept changes because sites and UEs in that model are somehow systematic. Applying a standard optimization criterion for real network is more complex due to different conditions such as; elevation, sites location, users distribution and antennas height. We simulated two main types of coordination in the real COMP network us. The first type is held between sectors within the same BS which is called intra-site coordination, and the second type is between a set of sectors which belong to different BSs. This type is called inter-site coordination. Both of them are assumed for non-overlapped clustering. We can simulate up to seven carriers and two horizontal and vertical polarizations, thus we have 14 unique RF and polarization air interfaces. Using the same carrier causes different types of interference, and the practical system model has more than 14 clusters in both intra-site and inter-site coordination. The demands here are more than the available resources because there are only 14 unique RF and the number of clusters is more than 14. Reuse of frequency spectrum and reduced cell size has to be implemented. This may lead to an increase in the interference level in the multi-cell networks. Applying frequency reuse should occur between geographically separated clusters to prevent any overlapping between the spectrum resources as the interference and distance between clusters are inversely related.

4.1 Inter-site clusters coordination

The real system network contains of 20 sites with 60 cells. We simulated this system design by using 23 clusters in the inter-site coordination type. Choosing the 23 clusters in this stage is primary based on sector locations where some of them are in the network borders and the others in the middle of the network.23 clusters network coverage, the clusters are of various sizes because of non-uniform ISD and real network distribution. Since there are 23 clusters and 14 unique RF parameters, we reused 9 RF parameters in different clusters, and only 5 clusters have unique RF parameters. The downlink interference differs from one cluster to another. Less interference exists in the 5 clusters which have unique RF parameters while the interference is higher in the remaining 18clusters because their RF spectrum has been reused twice. Despite of the benefits of using frequency reuse technique, UEs still suffer some interference between the sectors in the networks especially in short ISD networks. UEs in the middle of the network experience higher interference because they are affected by many undesired signals from near sectors while the UEs in the network edge receives less undesired signals.

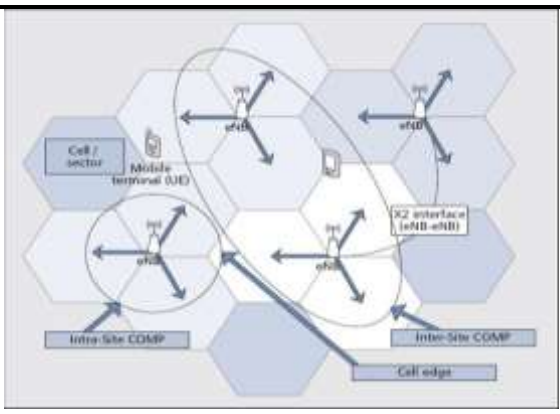

Figure 4.Inter-site and intra-site clusters coordination

4.2. Intra-site clusters coordination

The coordination in intra-site clusters takes place on the BS level where all BS cells belong to one cluster. The number of the clusters in intra-site coordination is equal to the number of sites, which equal 20 sites in the practical system model. The 20 intra-site clusters in the network where each colour refers to one cluster. Frequency reuse is applied in the intra-site coordination case also, where there are 6 clusters with reused RF parameters.

V.CLUSTERING TAXONOMY BASED ON SELF ORGANISATION

In this field, COMP clustering algorithms in literature are critically discussed based on self organisation. Three main clustering types are identified:

1) Static Clustering
2) Semi-Dynamic Clustering
3) Dynamic Clustering

Static clustering method is less complex with less signalling overhead but this method is not responsive to changes in the network nodes or user locations, hence the performance gains are limited[4]. Semi-dynamic clustering is an expanded version of static clustering where a number of static clusters are formed and employed dynamically to improve the potential gains. Complexity increases with additional signalling but working method is also improved when compared to static clustering. However, this approach still lacks on exactly responding to the dynamic changes in the cellular network. Dynamic clustering methods are developed to respond to network and user mobility changes, i.e., new sites, sleeping cells, load changes etc. This plan comes with increased complexity on scheduling and beam forming design but it gives the best results, reducing inter-cluster interference by moving the clusters dynamically. Dynamic clustering can be classified in three major sectors within itself based on the method. Hybrid method combines both methods which can be a good balance of complexity vs. performance. In the subsequent sub methods, we present an extensive literature review for each category and criticise available techniques based on complexity, scalability and potential spectral efficiency gains.

5.1 Static Clustering

COMP coordination clusters are arranged in a static way, almost depend upon topology and cannot change according to changes in the network system. This kind of approach offers a less complex derivation which can be a good candidate to deploy in the starting phase of LTE-A deployment. Static clustering within cells in the co-located site is the most primary and practical opportunity which does not need data exchange between the sites, hence not reliant on fast backhaul. The work presented in proposes a static clustering scheme, where sectors looking into each other are clustered to improve SINR. Authors consider a hexagonal grid in deployment which is non-realistic in real network deployments. Static intra-site and inter-site COMP clustering is assumed with orthogonal frequency reuse where antenna bore-sights are changed to face into each other for additional COMP gain. Dead-spots would be designed with this new topology where small cells are suggested to complete in the dead-spots. COMP and HetNet deployment are combined in this solution to find locations for small cell deployment, however an idealistic hexagonal grid considered again, which is unrealistic. A disjoint and overlapped static clustering method is presented in where static clusters are organised to maximise mean SINR or to minimise SINR outage at possible user locations. In the overlapped solution, one cell can be in three clusters where system resources are divided into each of the three clusters. Activated solution is better than the clustering types depends on regular patterns as it can choose to realistic network topology. However, the proposed work is not scalable as the complexity of the solution increases with the number of possible user locations Z.Authors have checked an inter-cell interference model in HetNet scenario with Pico-cells to offload macro network. Time-domain resource partitioning is assumed between the macro BS and Pico layer within the macro BS's coverage area. A static CB-COMP method is practiced with centralised beam forming and arranged for the cluster of all Pico-cells and its connected macro cell. COMP failed to improve the performance further from enhanced inter-cell interference coordination (eICIC) due to the additional overhead required to implement COMP, i.e., mainly the UERS signal introduced with COMP in LTE-Advanced. Time synchronisation limitation between coordinated cells is tested. In summary, static clustering is an attractive method with its significantly minimum complexity for beginning COMP deployment for LTE-A networks. Intra-BS COMP is a promising solution which avoids the need for maximum backhaul bandwidth requirement between the BSs. On the other hand, inter-BS static clustering algorithms are mostly depends on the consideration of hexagonal grid layout, which is not suitable to real networks. Furthermore, this approach will fail to provide the much needed spectral efficiency gains and increased model capacity for future 5G networks. Semi-dynamic and/or fully dynamic solutions are needed to respond to changing network/user profile conditions and high COMP gains.

5.2 Semi-Dynamic Clustering

Semi-dynamic clusters are more extreme than static clusters where several layers of static clusters are created to avoid inter-cluster interference. More than one static clustering pattern are organised where users are able to choose the most comfortable cluster. This approach also mostly relies on hexagonal grid network topology which is unrealistic in practical system networks. A two layer static clustering, based on regular network topology is proposed in to extend on static clustering. This approach is then elaborated for several layers for dynamic clustering. It's proposed for users to pick one of the available clusters based on power. While the solution is an enhanced algorithm when we compared to static clustering, overlapping nature of the proposed algorithm adds to the scheduling complexity and require increased backhaul bandwidth. A semi-dynamic clustering scheme is introduced in where static clusters are formed based on hexagonal grid topology and multiple shifted cluster patterns are created with different sub-channels allocated for each shifted cluster. A joint, centralised scheduling is advanced for this clustering type. Static cluster shift idea from is further enhanced with "full shift" and different frequency bands are allocated on shifted clusters. Static clusters are designed to maximise near cells in the same cluster for a provided hexagonal network layout. Shifted clusters minimise the inter-cluster interference, maximising the COMP gain, however solution is depends on hexagonal grid topology which is not suitable to real networks. Semi-dynamic clustering method is suggested for downlink Time Division Duplex (TDD) JT-COMP scenario. Solution is depends on large size (nine cells) static clustering and creating various static patterns of sub-clusters in each and every large static cluster. Dynamically choosing sub-clusters achieves almost as good as big cluster spectral efficiency but with minimised complexity. Proposed method is not able to respond to dynamic changes within the static cluster, i.e., new/sleeping cells etc. and also static nature of the big clusters will design inter-cluster interference. In summary, semi-dynamic clusters are an enhanced version of static clusters with minimal overhead increase, however most solutions are based on idealistic hexagonal grid topology which is not realistic. Furthermore, majority of semi-dynamic algorithms offer orthogonal frequency allocation from each and every cell to its designed static clusters. Depends on the utilisation of dedicated bandwidth for each and every static cluster, proposed algorithms can minimise the overall spectral efficiency. Moreover, Static nature of clusters is not able to react fully to the spatio-temporal changes in user profiles and the network elements. Dynamic clustering algorithms is explained in the next section which is mostly suitable to real network topology and can dynamically accept to changing user profile and network conditions.

5.3 Dynamic Clustering

Dynamic COMP clustering is more complex with enhanced signalling overhead but its more responsive to the changes in the network system [5]. Inter-cluster interference can be minimised and cluster size for single users can be optimised dynamically for an optimum balance. Dynamic COMP clustering can be derivate in three groups depends on network elements considered for clustering:

1) Network-Centric Clustering
2) User-Centric Clustering
3) Hybrid Clustering

VI.COMP CLUSTERING

6.1 Network-centric clustering

Cells are grouped into clusters where COMP takes place within each cell cluster, i.e. users are assigned cells from within the cell clusters only. Users which are located at the cluster boundary will experience interference from cells out-side of the cluster. This type of clustering reduces the additional overhead and complexity from COMP, but COMP gain is compromised due to inter-cluster interference.

6.2 User-centric clustering

There is no network-centric clustering, but users are allocated groups of cells for cooperation, so each user is provided its own user-centric cluster of cells [13]. There is no limit on which cells to be selected for each user. This type of clustering maximizes the COMP gain, however the COMP over-heads and complexity is very high.

Figure6: User-Centric, Network-Centric, Hybrid Clustering

6.3 Hybrid clustering

This type of clustering utilities both approaches above, employing a network-centric clustering to group cells into clusters first to reduce COMP implementation complexity and overheads, and deploy user-centric clustering within each of the network-centric cluster where users are allocated their own individual group of cells within the network-centric cluster for cooperation[6]. This approach provides a balanced approach where complexity/overheads for COMP are reduced and COMP gain is relatively high with user-centric clustering model operating within each network-centric cluster.

VII.CONCLUSIONS

This paper proposes a clustering algorithm in the coordinated multipoint. This proposed algorithm tackles the spectral efficiency and load balancing mechanism. This scheme followed by open research areas in dynamic clustering approaches, reviewing the challenges on complexity/gain trade-off of dynamic clustering and the need for comprehensive COMP clustering solutions to maximise not only spectral efficiency but also other system objectives like load balancing and energy efficiency.

VIII. FUTURE WORK DIRECTIONS

Future research directions can include more and more practical technical problems to further enhance JP-COMP performance outcomes. The imbalance conditions, i.e., the UE imbalance in each and every cell and the power transmitting imbalance from each base station become interesting topics in this field.

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