Performance Improvement with Intra-site CoMP for C-RAN Networks

Yi Jin, InWhee Joe
Department of Computer and Software, Hanyang University
e-mail : jinyi35@hanyang.ac.kr

Abstract

Coordinated multi-point（CoMP） transmission adopt the Base Stations（BS） cooperatively process User Equipment（UE） connected to multi-points to improve UEs spectral efficiency at the cell edge and eliminate the inter-cell interference（ICI）. This technology is important for UEs at the cell edge. Considering the real environment, energy consumption and cost situation, we propose in a Local C-RAN architecture deployment of CoMP and observed its spectral efficiency and Signal-to-Interference and Noise Ratio (SINR) in intra-site CoMP scenarios. Simulation results show that this approach has significantly enhanced than Non-CoMP.

1. Introduction

OFDM and MIMO technology, through the high-rate data divided a number of low-rate data. Modulation onto the set of orthogonal subcarriers to transmitted, it can effectively eliminate the interference within the cell. However, in order to obtain higher spectral efficiency, the system uses the same frequency networking mode. So that UEs at the cell edge will receive the co-channel interference from the adjacent cell, severely limits the throughput and quality of service in edge, and OFDM technology cannot effectively eliminate inter-cell interference (ICI). Thus CoMP will be better solve these problems.

2. Related research

A. CoMP species

According to the relation between the nodes coordinated, CoMP can be divided into:

(1) **Intra-site** CoMP collaboration occurs within a site, at this time there is no return capacity constraints, so it can interact with a lot of information across multiple cells of the same site.

(2) **Inter-site** CoMP collaboration occur across multiple sites, thus for backhaul capacity and delay must be need high requirements.

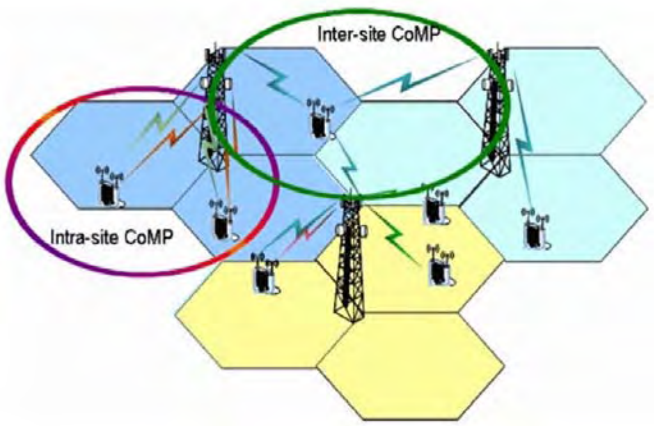

Figure 1

Intra-NeB just consider the eNB processing delay, so processing delay is much shorter, because not to exchange complex coordination signal through the X2 interface, between sites collaborative process had no additional overhead. Compared to the inter-site collaboration, cooperation within the station to get a larger gain and joint transmission network throughput and spectral efficiency is also improved.

According to the base station side whether to share the user's data, coordinated multipoint transmission technology is mainly divided into two situations:

(1) joint transmission (JP: **Joint Processing**)

(2) Collaboration scheduling/beamforming (**Coordinated Scheduling**/**Beamforming**)

Since inter-cell packet without sharing, so coordinated scheduling is not strictly limited backhaul capacity. But the communication information like the channel state information, Hybrid automatic repeat request (HARQ) acknowledgment message makes backhaul delay on the performance impact is still very serious. Therefore, the coordinated scheduling seems more suitable for intra-site collaboration scenarios.

Using the JP technology to improve UE's throughput and reduce interference in a cell edge is very popular. But JP techniques need to share UE's data between the Base Station, each base station by sharing data, joint transmission data to one or more users. It is more suitable for use in inter-site environment. And since processing the information was too many and complex, so traditional C-RAN will be more suitable.

B. Cloud radio-access

The Centralized, Co-operative and Cloud RAN (C-RAN) architecture [1] has many significant benefits.

Energy efficiency: The power consumption of site support equipment can be largely reduced due to the consolidation of baseband unit (BBU) processing.

Capital expenditure (CAPEX) and operational expenditure (OPEX): The pooling of BBUs allows centralized management and operation, leading to significant cost savings on site rental as well as operation and maintenance.

Capacity: More advanced transmit and receive wireless communications technologies can be implemented using the C-RAN infrastructure, leading to remarkable network capacity improvements.

Traffic offloading: BBU pooling can serve as a natural local breakout point to offload core network traffic to different network nodes as well as different radio access technologies if available.

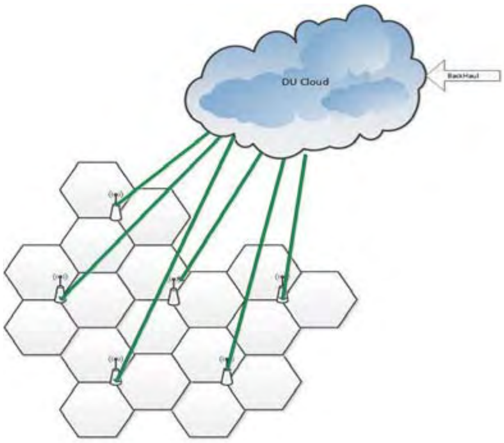

Figure 2 original C-RAN

Fig. 2 shows design for C-RAN [2]. The BBU pool is placed at a central location for flexible resource scheduling and interference coordination. However, this architecture is not suitable for densely populated urban areas, although BBU pool reducing the number of base stations, but establishment of a BBU pool for processing information from a plurality of cells also need to occupy a lot of space, and its operation will be very complicated.

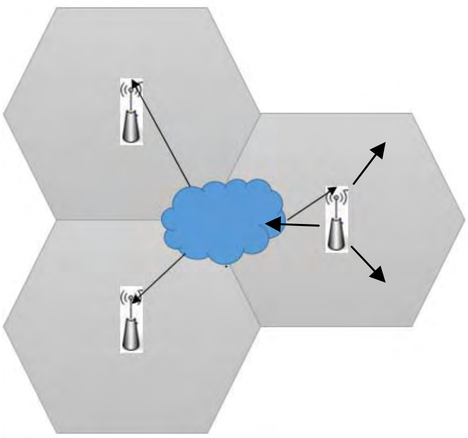

Figure 3 BBU locally centralized (local C-RAN)

Fig.3 shows a new C-RAN approach, called local C-RAN [3]. This approach is relatively uncomplicated, does not take up too much place and compared to original C-RAN more suitable for intra-site CoMP scenarios. And this situation is very suitable for small cell heterogeneous network (HetNet) deployments.

3. System Models

While increasing the performance in cell edge is very important, but consider that in densely populated cities, the traditional C-RAN take up a lot of space is a problem. According to share different information, CoMP has many sharing scenarios. Many publications have shown how CoMP mitigates interference and improves both the data rate and the spectral efficiency in ideal networks.

In this paper we structure a local C-RAN, and the use of Coordinated Scheduling to improve the communication quality of UE's in cell edge. It does not require very complex calculations, and adequate support Coordinated Scheduling. Finally we using the SINR to confirm whether to increase. SINR is one of the main aspects that should be optimized in any wireless communication system.

In the system model [4], we address some important parameters such as path-loss, antenna pattern and SINR. In the considered ideal network layout, each BS serves three hexagonal cells using three directive antennas. Each antenna covers one cell area, and the azimuth for each antenna is beaming 120 degrees out of phase from the neighboring antenna in the same BS. Serving cell selection criteria depends on UE downlink received power. Hence, the UE will be served from the sector which supports this UE with the highest Received Signal Level (RSL).

Considering a flat-plane path-loss, PL, model

$$PL = 130.5 + 37.6log_{10}\left(\frac{d}{km}\right) \quad [dB] \qquad (1)$$

And d refers to the distance between the UE and the BS. The path-loss exponent in equation (1) equals to 3.7assuming shadowed urban areas.

The antenna pattern depends on the angle, θ, between the antenna azimuth and UE, the front-to-back ratio of the antenna and the maximum possible attenuation (Am), and the 3dB main lobe beam-width, $\theta 3dB$. The antenna pattern equation can be defined as in:

$$AL(\theta) = min\left(12\left|\frac{\theta}{\theta_{3dB}}\right|^2, Am\right) \quad [dB] \qquad (2)$$

The number of sectors per BS is affected by the values of $\theta 3dB$ and Am. In our case, each BS consists of 3 sectors with an antenna gain equals to 14 dBi where $\theta 3dB$ and Am are 70 degrees and 20 dB respectively. Each sector has directional antennas with 120-degree beam-width.

CoMP technique improves the UEs SINR values and reduces the interference at cell edge, where appropriate network optimization that care about choosing the coordinated sectors in CoMP systems can enhance the network efficiently. Considering J UEs and M cells. The experienced SINR by a UE j from the serving cluster $M`$ is formulated as:

$$SINR_j^{M'} = \frac{P\sum_{m\in M'}\gamma_j^m}{P\sum_{m\in(M/M')}\gamma_j^m + \sigma^2} \qquad (3)$$

4. Simulation& Results

In this section, the performance of the proposed BBU+RRU based CoMP system is evaluated by system level simulation.

parameters	value
Layout	20 sites with 3 cells
Inter-site distance	500 m
Carrier Frequency	20 MHz
Bandwidth	20 MHz
UE Noise Figure	6 dB
Antenna Gain	11.6 dBi
Resolution of	810m
Sampling rate	380/250
Subcarrier spacing	15 KHz
DL/UL subframe ratio in 5ms	2DL / 2UL
Max Tx power	40 dBm
BS antenna height	15 - 35 m
FFT size	1024

Table 1

SIMULATION PARAMETER

We simulated 20 BSs using one of the LTE frequencies which is 2.6 GHz and 20 MHz for bandwidth, and using hypothesis BSs locations. Each sector maximum transmitted power is 40 dBm which is a reasonable level of power that can be used in urban networks. Table 1 briefs the used parameters. These parameters are feed to the propagation modeling software.

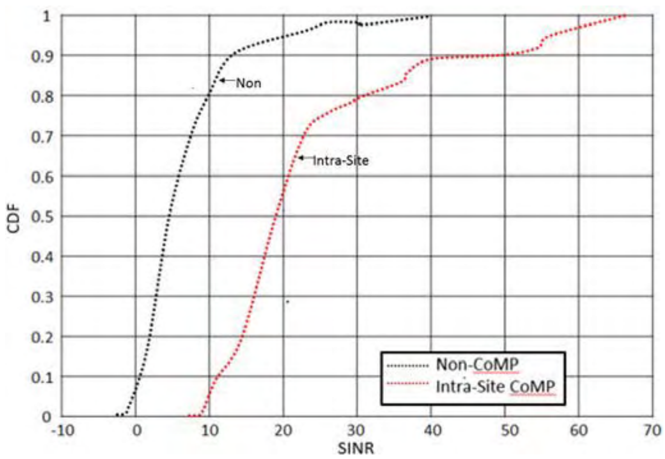

Figure 4 Network SINR CDF comparison between using CoMP and Non-CoMP approaches

5. CONCLUSIONS

In this paper, we propose a relatively uncomplicated and can save energy consumption- Local CRAN environment and using the coordinated scheduling. Simulation results show that this method has been improved in performance than not use.

Reference

[1] China Mobile Research Institue, “C-RAN: The road torward green RAN”, White paper, 2011.

[2] Aleksandra Checko ; MTI Radiocomp, Hillerod, Denmark Henrik L. Christiansen ; Ying Yan ; Lara Scolari ; Georgios Kardaras ; Michael S. Berger ; Lars Dittmann “Cloud RAN for Mobile Networks—A Technology Overview”, Sep. ,2014, IEEE Communications Surveys & Tutorials.

[3] Huaning Niu; Clara Li; Apostolos Papathanassiou; Geng Wu “RAN architecture options and performance for 5G network evolution”, April, 2014, IEEE.

[4] P. Marsch and G. Fettweis, “Static Clustering for Cooperative Multi-Point (CoMP) in Mobile Communications” in Communications (ICC), 2011 IEEE International Conference on, 2011.