

The Management Method of Multi-carrier for Multicast services

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Abstract— In a multicast service, even though one of mobiles is in a very bad channel condition, it is certainly needs satisfying the mobile which joins the service. However, the way to accommodate it results that the throughput of the service is decided and limited by the channel state of the worst mobile. So the capacity of mobiles with good channel states is determined by the worst mobile. For overcoming the capacity limitation, we propose the management method of multi-carrier for multicast services in this paper. BS performs the multi-carrier management based on admission control on adjacent component carriers. The admission control restricts mobiles to access some component carriers (CCs). The method provides discriminated service qualities to mobiles with good channel condition and supports requested services to them with bad channel state simultaneously. The proposed method satisfies mentioned precondition about multicast services and improves throughput performance compared to the method, which has no admission control.

Keywords— multicast, multi-carrier, admission control, carrier aggregation

I. INTRODUCTION

Supporting multicast services, which adopt multicast transmissions to efficiently utilize radio resources, are a challenging problem in wireless networks due to different channel conditions of mobiles. One solution is to transmit data based on the worst case user, which causes inefficient use of radio resources [1]. Although some mobiles in a multicast service have better channel qualities than others, they must be subject to the same transmission rate decided by the mobile with the worst channel quality. The problem is how to satisfy all mobiles with different channel conditions without sacrificing the throughput performances of mobiles with good channel states. For multicast services, how to solve the problem should be considered.

In order to support the transmission over wider bandwidth e.g. up to 100MHz, the IEEE 802.16m and the LTE-Advanced system introduces the carrier aggregation technology, where two or more CCs belonging to adjacent frequency bands or different frequency bands can be aggregated [2]. With the carrier aggregation technology, it is possible to schedule a user on multiple CCs simultaneously. To efficiently allocate the users on different CCs, some papers employ balancing the load across CCs [2][4]. One of those papers employs Layer-3 carrier load balancing, which places emphasis on dividing users equally on the number of CCs [3]. In this paper, we emphasize not user-based load balancing but multicast

service-based admission control on CCs to solve the above mentioned problem of multicast services. The proposed method achieves the attainments of increasing the throughput of mobiles depending on the channel states in multicast services and supporting the mobile in bad wireless conditions.

II. SYSTEM MODEL

In this paper, we consider a downlink multi-carrier wireless system with a cluster which consists of a center cell and eighteen surrounding cells. Each cell includes a BS with three sectors, mobiles and service ids with which BS offers mobiles multicast services. The mobiles are uniformly dropped within a sector. Only one service id is allocated to a mobile in consecutive order when it is distributed in the center cell. The number of users which join a multicast service id is fixed, but it is changed, depending on the number of service ids. In the MBS-zone, with every sector of BS synchronized and transmitting the same information, the signal from different BSs coherently combines at the mobile to provide improved SINR. The BS in the center cell could be the same MBS zone or not with BSs of surrounding cells. There is no interference in the MBS-zone since all BSs transmit the same signal. However, the effect of multipath is magnified due to the fact that signals from different BSs take different paths and experience different propagation delays [5]. The mentioned effects of MBS-zone and multipath are considered in this system level simulation.

The carrier aggregation of adjacent CCs is described below. For example, two CCs f1 and f2 belonging to same frequency band have the same transmitting power and the coverage of f1 is same as that of f2. Each of adjacent carriers is divided into N subcarriers, which are shared by only K multicast service ids except unicast services. N subcarriers divided into V resource blocks. Each of resource blocks (RBs) consists of several RUs (resource unit). The RB is the smallest allocation unit in frequency domain for multicast services. Fixed I-subcarriers are included in a RU. When a BS is scheduling resources, we apply the TDD frame structure of 802.16m. The basic frame structure is consisted of four 20ms-superframe, each superframe contains four frames, each frame is consisted of eight AAL subframes and each of AAL subframes contains 5 or 6 OFDM symbols. Only five subframes are available for a downlink transmission. Fourth-fifth of DL subframes is allocated for traffic scheduling and the remaining RUs are reserved for carrying control information. In this simulation,

the RUs reserved for control information are not included to allocate DL traffic data.

The mobiles request a wanted multicast service and each service with its unique id collects mobiles to join the service. The BS in the center cell schedules RBs of adjacent CCs at each 5ms- interval and allocates them to each of service ids. But the number of mobiles, which is contained in one of service ids that are assigned onto RBs of adjacent CCs, is controlled by the BS, depending on their channel states. In the next section, we will describe how to perform admission control on adjacent CCs.

III. RESOURCE ALLOCATION AND ADMISSION CONTROL OF CCs FOR MULTICAST SERVICES

In adjacent intra band aggregation, where the aggregated carriers belong to same frequency bands, the fading characters are similar between carriers. The BS corrects SINR information on one of CCs in order to assign RBs of CCs. At first, we list some notations to write some mathematical formula down.

- k index of users in multicast service ids, $k \in (1, 2, 3, \dots, K)$.
- m index of BSs in a cluster, $m \in (1, 2, \dots, M)$.
- n index of subcarriers for the downlink channel, $n \in (1, \dots, N)$.
- s index of multicast service ids in a cell, $s \in (1, 2, 3, \dots, S)$.
- c index of CCs in a cell, $c \in (1, 2, 3, \dots, C)$.

To calculate SINR of a mobile, k, we need to define the following parameters. Let P_{Tx}^m denote the total transmit power from m-th BS, P_{loss}^m denote the distance-dependent path loss including shadowing, antenna gain/loss and cable losses from m-th BS and H_n^m denote the channel gain for a mobile in a subcarrier n.

Because dropped mobiles exist in MBS zone region, the mobile which exists in the MBS Zone_ℓ receives signals from not only from self-serving BS for k, m_k, but also other BSs, m, where MBS Zone_ℓ = {m | each m ∈ MBS Zone_ℓ}. The received $SINR_n^k$ of a mobile k at a subcarrier n can be calculated by equation (1). Signals from BSs, each m ∈ MBS Zone_ℓ is calculated as interferences and expressed as a denominator, where N₀ is awgn noise. In equation (1), Num(MBS Zone_ℓ) represents the number of BSs of the MBS Zone_ℓ and nmz /nmz are increased one by one if those parameters satisfies each conditions.

$$SINR_n^k = \frac{\sum_{m=0, nmz < Num(SurroundingBS) - Num(MBSZone_\ell), m < M} P_{Tx}^m \cdot P_{loss}^m \cdot |H_n^m|^2 + \sum_{m=0, nmz < + [if, m \in MBSZone_\ell, m \neq m_k]} P_{Tx}^m \cdot P_{loss}^m \cdot |H_n^m|^2}{\sum_{m=0, nmz < + [if, m \in MBSZone_\ell]} P_{Tx}^m \cdot P_{loss}^m \cdot |H_n^m|^2 + N_0} \quad (1)$$

As the link level curves are generated assuming a frequency flat channel response at given SINR, an effective SINR is required to accurately map this system level SINR onto the link level curves to determine the resulting BLER.

By accumulating all SINR values of RB_j subcarriers, we can get effective SINR, $effective SINR_{RB_j}^k$, for a mobile in a resource

block j by equation (2). Num(RUs) represents the number of RUs, β is adjustment parameter and I is the fixed-number of subcarriers.

$$effective SINR_{RB_j}^k = \frac{-\beta \cdot \log\left(\sum_{n=0}^{I \cdot Num(RUs)} \exp\left(-\frac{SINR_n^k}{\beta}\right)\right)}{I \cdot Num(RUs)} \quad (2)$$

Active K-mobile would calculate effective SINRs of all RBs to send their channel states to the serving BS. To restrict transmission on the amount of control information, the scheduler of BS can transmit only two containers for control information in this paper. So each container can contains the allocation information on two several-consecutive RBs, two non-consecutive RBs or one several-consecutive RBs and one non-consecutive RB.

To perform controlling on adjacent CCs, the admission control classifies multi-carriers, c, which are available in the system, into two kinds of carriers, that is, primary and secondary carrier. The primary carriers are permitted to be accessed by all mobiles.

A. Resource Allocation in the primary CCs

In the primary CC, the BS choose the worst mobile which is contained in the service id, s, by sorting effective SINRs per each RB. The channel state of the mobile, is selected by equation (3), is used following equations (4), (5), and (8) to decide which service id is assigned to a RB.

$$Sid(j)_{RB_j}^{s, max-j} = \arg \min_k \{effective SINR_{RB_j}^k\} \quad (3)$$

To choose the service id to allocate RB_j, the BS employs three kinds of scheduling method, RR, MT and PF. In RR case, the BS selects the service id sequentially without considering channel states.

$$SB(j)_{j=0}^{max-j} = Sequential \{Sid(j)_{RB_j}^s\} \quad (4)$$

In MT case, the BS selects the service id with maximum throughput given RB_j.

$$SB(j)_{j=0}^{max-j} = \arg \max_s \{Sid(j)_{RB_j}^s\} \quad (5)$$

In PF case, the BS calculates expected data rates, $rate(Sid(j)_{RB_j}^s)$, given effective SINR by equation (6) and average data rate, $avg(Sid(j)_{RB_j}^s)$, for a service id by equation (7). To get expected data rate, PF scheduler defines parameters, AllocatedRS and MCS level. AllocatedRS represents expected assigned resources and $MCSLevel(Sid(j)_{RB_j}^s)$ means the amount of reliable transmitting bits in the wireless environment. Average data rate is continuously calculated during the simulation time, T_s.

$$rate(Sid(j)_{RB_j}^s) = AllocatedRS \cdot MCSLevel(Sid(j)_{RB_j}^s) \quad (6)$$

$$avg(Sid(j)_{RB_j}^s) = avg(Sid(j)_{RB_j}^s) \cdot \left(1 - \frac{1}{T_s}\right) + rate(Sid(j)_{RB_j}^s) \cdot \frac{1}{T_s} \quad (7)$$

PF scheduler selects the service id which satisfies equation (8).

$$SB(j)_{j=0}^{max-j} = \arg \max_s \left\{ \frac{rate(Sid(j)_{RB_j}^s)}{avg(Sid(j)_{RB_j}^s)} \right\} \quad (8)$$

At first, we calculate the throughput of each service id and summarize them for the throughput of the BS for mobile k. The throughput of each service id calculated by considering selected mobiles' assigned resource, transmitting bits per subcarrier and BLER, which is resulted from the above mentioned link level curves given the effective SINR.

$$\text{Throughput}(m_k) = \sum_{s=0}^S \text{Throughput}(s) \quad (9)$$

B. Resource Allocation in the secondary CCs

The secondary carriers are restricted to be accessed by mobiles. Even though the mobiles joins same service id, only some mobiles with good channel condition are permitted to access primary and secondary carriers. Only some mobiles among all active K mobiles are selected by BS to receive traffic through secondary carriers, where $k \in (1, 2, 3, \dots, K)$. BS selects mobiles from the list of each service id equation (10). Mobiles of which signal length of RB_j is smaller than fixed threshold lose the right to receive data through RB_j , the secondary CCs and each service id eliminates those mobiles from its list of the CCs.

$$b_{c,ccs-ccs}^k(RB_j) = \begin{cases} 1, & \text{if } [\text{threshold} < \text{effective SINR}_{RB_j}^k] \\ 0, & \text{if } [\text{threshold} > \text{effective SINR}_{RB_j}^k] \end{cases} \quad (10)$$

In secondary carriers case, if $b_{c,ccs-ccs}^k(RB_j)$ is zero, the mobile, k, could not proceed as planned equations (3) ~ (9). By equation (10), BS performs the multi-carrier management based on admission control on adjacent CCs. That is, every multicast service ids can be assigned all CCs simultaneously, but every mobile does not have the right to access any carriers for multicast services. With mobiles' signal strength, the admission control restricts mobiles to access some CCs. Therefore every mobile does not have the right to access any CCs, but some of carriers are permitted by all mobiles. The right to access carriers is decided by not mobiles but the BS which controls them.

IV. SIMULATION RESULT

To evaluate the performance, there are two component carrier to be aggregated and f1 = 2.3GHz, f2 = 2.5GHz, and the operation bandwidth of each carrier is 10MHz. Both of them have the same transmitting power. The other simulation parameters are listed in TABLE 1.

TABLE 1. SYSTEM SIMULATION PARAMETERS[5]

Parameter	Value
Site Layout	3-sectorized Hexagonal grid with 7cells wrap-around
Height of BS	38 meter
Distance-dependent path loss	$PL = (44.9 - 6.55 \log_{10}(hBS)) \log_{10}(d) + 26.46 + 5.83 \log_{10}(hBS) + 26 \log_{10}(f[\text{GHz}]/2)$, d and hBS in meter,
Lognormal shadowing	Gaussian distribution with zero mean and standard deviation 8 dB

Horizontal antenna pattern for 3-sector cell sites with fixed antenna patterns	$A(\theta) = -\min \left[12 \left(\frac{\theta}{\theta_{3dB}} \right)^2, A_m \right]$ $\theta_{3dB} = 70 \text{ deg } ree, A_m = 20 \text{ dB}$
Mobile location	Uniformly dropped in a center cell
Mobile speed	60% : 3km/h, 30% : 30km/h, 10% : 120km/h
Total BS Tx power	46dBm
Antenna configuration	1 by 1
Channel Model	60% : Pedestrian B, 40% : Vehicular A
Minimum distance between mobile and cell	35meter
Thermal noise spectral density	-174 dBm/Hz
Traffic Model	Full buffer

The simulation time is 0.5sec, the unit of resource allocation (RB) is 6PRU, the total number of mobiles is 90, but the number of mobiles which is counted in a service id is changed by depending on the number of service ids. In Figure1 and 2, the number of service ids is increased from 7 to 16 and f1 is a primary carrier, but f2 is a primary carrier or a secondary carrier. Following Figure 1 shows the BS throughput of f1 and f2, f1 and f2 are primary carriers. From Figure 1, the throughput of each service id is similar in f1 and f2 and MT scheduler shows the largest throughput among schedulers.

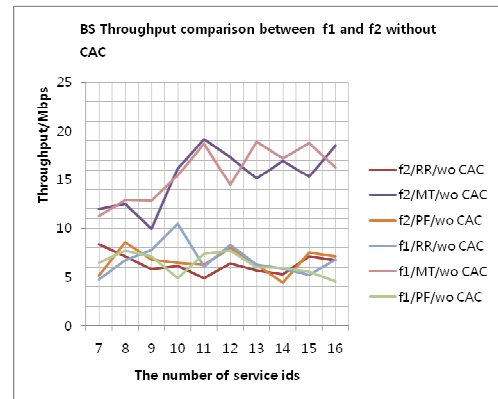


Figure 1. BS Throughput comparison between f1 and f2 without CAC

Figure 2 shows the BS throughput comparison between with and without CAC. According to the result from Figure 2, the BS throughput are 21Mbps for f2 PF with CAC(carrier admission control) and 6.2Mbps for f2 PF without CAC in case of service id = 12.

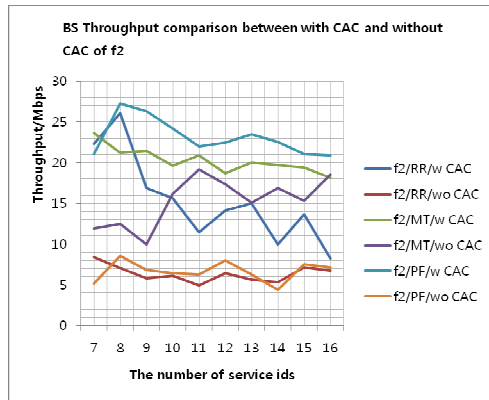


Figure 2. BS Throughput comparison between with CAC and without CAC of f2

The simulation results show the performance difference between with the management method of multi-carrier or not. Another important thing is that the performance of PF is be far superior than that of MT. Therefore we can achieve both fairness and performance in this paper.

V. CONCLUSIONS

we emphasize the multicast service-based admission control on CCs to solve the problem of multicast services. The proposed method supports the mobile in bad wireless conditions and achieves both fairness and performance of BS.

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