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영역/시간 세분화 D-TDD OFDM 구조에 기반한 새로운 WMAN 시스템 구조 설계

(Enhanced WMAN System based on Region and Time Partitioning D-TDD OFDM Architecture)

김 미 란*, 정 희 정*, 김 낙 명**

(Mee-Ran Kim, Hee-Jeong Cheong, and Nak-Myeong Kim)

요 약

미래 무선 멀티미디어 서비스에서 발생하는 비대칭 트래픽을 해결하기 위한 중요한 대안으로 동적 시간 분할 이중화 (D-TDD: dynamic time division duplexing) 기법이 대두되고 있다. 그러나 D-TDD 모드 셀룰러 시스템에서는 교차 시간 슬롯 (CTS: cross time slot) 구간 내에서 발생하는 기지국 (BS)간 그리고 단말기 (MS)간 간섭은 시스템 성능을 저하시킨다. 이러한 간섭을 완화하기 위하여 본 논문에서는 직교 주파수 분할 다중화 (OFDM) 시스템을 위한 D-TDD모드에서 동작하는 영역/시간 세분화 제어(region and time partitioning) 기법을 제안한다. 즉, CTS 구간에서의 각 타임슬롯을 일정 수의 미니슬롯들로 분할하고, 각 셀은 각 타임슬롯의 미니슬롯과 같은 수의 영역들로 분할하여, 각 사용자들은 자신이 위치한 영역에 따라 각각에 대응되는 미니슬롯을 할당받는다. 이와 같은 구조를 통하여 각 셀에서 간섭의 요인이 되는 인접요소들을 배제시키고, 역방향 간섭을 주는 요인들 간의 거리를 최대한 이격시킨다. 또 셀 간 간섭을 최소화하기 위하여, 신호품질을 고려한 시간 자원 할당 기법을 제안한다. 모의실험을 통하여, 제안된 기법은 기존의 시간자원할당 기법 대비 outage 확률과 대역폭 효율의 측면에서 보다 우수한 성능을 보임을 확인하였다.

Abstract

In accommodating the asymmetric traffic for future wireless multimedia services, the dynamic time division duplexing (D-TDD) scheme is considered as one of the key solutions. With the D-TDD mode, however, the inter-BS and inter-MS interference is inevitable during the cross time slot (CTS) period, and this interference seriously degrades the system performance. To mitigate such interference, we propose a region and time partitioning D-TDD architecture for OFDM systems. Each time slot in the CTS period is split into several minislots, and then each cell is divided into as many regions as the number of minislots per time slot. We then assign the minislots only to the users in its predefined corresponding region. On top of such architecture, which inherently separates the interfering entities farther from each other, we design a robust time slot allocation scheme so that the inter-cell interference can be minimized. By the computer simulation, it has been verified that the proposed scheme outperforms the conventional time slot allocation methods in both the outage probability and the bandwidth efficiency.

Keywords : dynamic time division duplexing, time slot allocation; cross time slot, orthogonal frequency division multiple access.

Ⅰ. Introduction

Recently, wireless packet data services are provided over wireless MAN (WMAN) for users to support higher data rate services. As the demands for multimedia services in the next generation wireless communication systems increase, the amount of traffic in the downlink tends to exceed the amount of traffic in the uplink. To support asymmetric traffic efficiently, the time division duplexing (TDD) scheme is a preferred duplexing method in the systems such as IEEE 802.16, WiBro, and UTRA-TDD. Especially in the dynamic TDD (D-TDD) mode, the switching

* 학생회원, ** 정회원, 이화여자대학교 전자정보통신학과
(Dept. of Information Electronics Engineering, Ewha Womans University)
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point, which is the boundary between downlink slots and uplink slots, is adaptively changed according to the downlink/uplink traffic variation.

In the D-TDD mode, however, the switching points of the cells depend on the dynamic nature of the traffic in each cell, so the cross time slot (CTS) period among neighboring cells is inevitable. The CTS period seen by a reference cell is defined as the set of time slots in which at least one of the neighboring cells is transmitting in the opposite direction. In the CTS period, the inter-MS co-channel interference (CCI), I_{MM} and the inter-BS CCI, I_{BB}, become serious, and they limit the performance of the D-TDD mode significantly. When the uplink users allocated in the CTS period in the neighboring cells are close to a downlink user allocated in the CTS period in the reference cell, I_{MM} towards the downlink user increases. On the other hand, when any of the neighboring cells are transmitting in the downlink, the reference cell base station (BS) receives I_{BB} from those cells and this limit the performance of uplink reception[1].

Recently, there have been several researches on time slot allocation (TSA) in the D-TDD mode. In [2], the maxmin{SIR} and max{SIR} TSA algorithms are proposed to suppress the CCI. The maxmin{SIR} algorithm is to maximize the minimum signal to interference ratio (SIR) by introducing extra uplink time slot region, while the max{SIR} algorithm is a simpler version of it. Since these algorithms utilize the estimated CCI for time slot allocation, the outage performance has been improved.

In [3], the different time slot allocation based on a region division (DARD) algorithm is proposed, which divides each cell into two regions as the inner region and the outer region. The BS allocates the resources in the CTS period to the MSs located in the inner region. In [4], the relative distances from a MS in the reference cell to the neighboring BSs are considered in allocating time slots. If the propagation path gains from the MS to the BSs in the neighboring cells are less than a given threshold, the resources in the CTS period can be assigned to the MS. This method, however, only considers the CCI from the BSs, excluding those from the MSs in the neighboring location has been proposed, which allocates the CTS period closest to the switching point to the nearest user from the BS. Among these algorithms, the performance of the TSA based on path gain and the performance of the TSA based on location are better than the others, so in this paper, we compare the performance of these two with our proposed TSA.

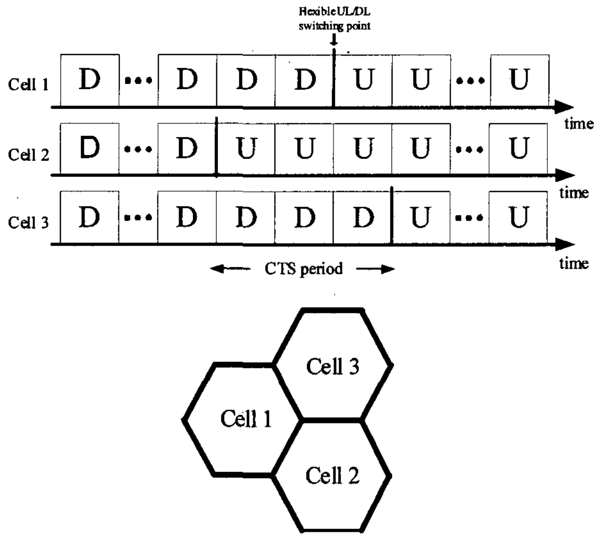

그림 1. 일반적인 D-TDD 시스템 구조.
U: 상향링크 시간 슬롯, D: 하향링크 시간 슬롯.
Fig. 1. A general D-TDD system structure.
U: uplink time slot, D: downlink time slot

In this paper, we propose a region and time partitioning (RTP) D-TDD architecture for OFDM systems. We introduce the concept of minislots in the CTS period. We divide each time slot in the CTS period into several minislots, and then define as many regions in each cell. Minislots are exclusively allocated to the users in the corresponding region, so that the CCI in the CTS period is reduced. Such architecture inherently separates the interfering entities farther from each other, and makes a robust time slot allocation (TSA) scheme possible so that the inter-cell interference can be minimized.

The rest of the paper is organized as follows. In section Ⅱ, the proposed system structure considered in this paper is described. Section Ⅲ introduces the proposed robust time slot allocation scheme in detail.

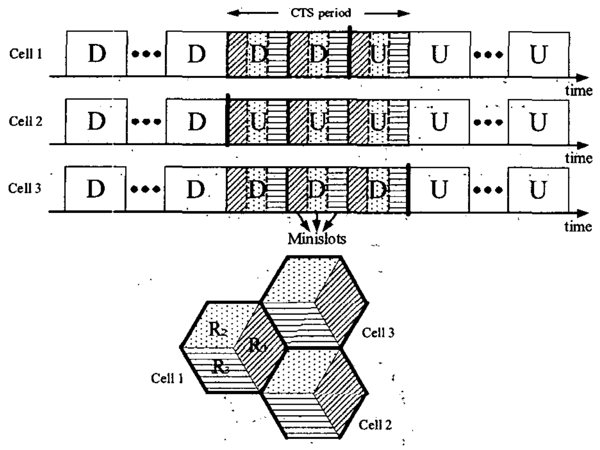

그림 2. 3-미니슬롯 구조의 제안된 RTP D-TDD 구조
Fig. 2. The proposed RTP D-TDD architecture for the 3-minislot case.

In section IV, the simulation results are discussed and the conclusion is made in section V.

II. Proposed System Architecture

A TDD frame is composed of a group of time slots for downlink traffic and another group of time slots for uplink traffic in sequence. In the D-TDD mode, the size of each group is dynamically changed according to the variation in the uplink/downlink traffic pattern. An example of a general D-TDD system structure is shown in fig. 1. Here, because of the difference in traffic demand in each cell, the CTS period is inevitably generated in any cell. In the CTS period, the multiple access interference from adjacent cells drastically increases, since the directions of transmissions are different from each other.

In this paper, we propose the RTP D-TDD architecture to mitigate the CCI in the CTS period. We divide each time slot in the CTS period into several minislots, and then define several regions in each cell in the same number as the number of the minislots per time slot. The regions are assumed to have equal degrees of angle. Each minislot is then exclusively mapped to its corresponding region in the cell. Fig. 2 shows an example of the proposed RTP D-TDD architecture when the number of minislots per time slot in the CTS period is three. Under the proposed architecture, users in each region transmit or receive data only in its corresponding minislots if any portion of their traffic has been assigned in the CTS period. For example, in fig. 2, the first minislot of each time slot in the CTS period is allocated to the users in the region of R1.

By applying the RTP D-TDD architecture, regions in each cell are mutually exclusively assigned to different minislots in each time slot in the CTS period. So, each region is free from the CCI from the adjacent regions, and the only CCI affecting one region in the reference cell is the CCI from the regions which are located at the same position in the neighboring cells and thus assigned to the same minislots. Therefore, the distances between the receivers in the reference cell and the interfering transmitters in the neighboring cells become longer, and this results in the reduction of the CCI in the CTS period. In the proposed RTP D-TDD architecture, it is assumed that a time slot is composed of several OFDM symbols in a multiple of the number of minislots per time slot. Either an omni antenna or sectored antennas can be applied to the architecture.

III. Robust Time Slot Allocation Based on Region and Time Partitioning

Along with the proposed RTP D-TDD architecture, we propose a TSA scheme which minimizes the inter-cell interference. The locations and the channel quality information of users in the reference cell are assumed to be perfectly known to the serving BS in the cell. We also assume that the BSs share their time slot state information among the neighboring BSs so that the reference cell BS can dynamically analyze the characteristics of the CTS period of the cell. The state information for each time slot represents one of three assignments, uplink traffic, downlink traffic or unassigned.

The proposed TSA based on RTP D-TDD architecture is composed of four separate steps; time partitioning step, region partitioning step, calculation of link gains, and allocating time slots. To perform the time partitioning, the reference BS first analyzes the characteristics of the CTS period. The BS gathers the time slot state information from the neighboring BSs, and then verifies the existence of the CTS period. Then, for each time slot of the reference cell, the BS compares the state of the time slot with those of collocated time slots in the neighboring cells. If any of the collocated time slots in the neighboring cells is opposite to the state of the time slot in the reference cell, the time slot of the reference cell is included in the CTS period. To complete the time partitioning, each time slot in the CTS period is then divided into a predefined number of minislots.

Each cell is then conceptually divided into several number of regions in as many as the number of minislots per time slot. The reference cell BS then groups the users into the region partitions according to their locations within the cell. So in this step, we group the users according to their regions where they belong to.

Next, the link gain for each user in the cell as a metric is calculated. The link gain is defined as a function of the estimated CINR for each MS. Here, the estimated CINR for each user in the cell includes the terms of channel gain, pathloss and the received interference from the neighboring cells. For the downlink user in the reference cell, IMM becomes severe since the interference comes from all the uplink users in the neighboring cells. And for the BS receiving signals from many uplink users in the reference cell, IBB becomes severe since the interference comes from all the downlink BSs in the neighboring cells. Using the information of locations and estimated uplink channel characteristics of the MSs, the BS evaluates the link gain for each user. The link gain calculation is repetitively performed over all the regions in the cell, and then the results are sorted separately for each region.

The final step of the proposed algorithm is allocating time slots to the most appropriate user. Here, we propose a TSA allocating the users having lower link gains to the minislots farther from the

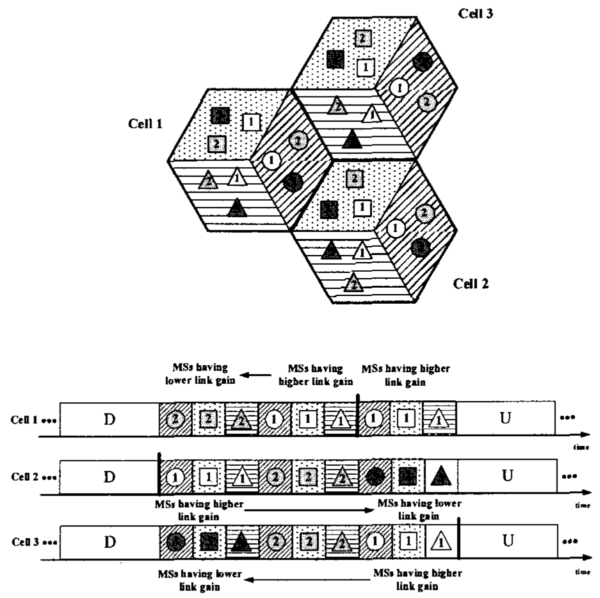

그림 3. 제안된 RTP D-TDD 구조에서 미니슬롯 할당의 예시.

Fig. 3. An example of the proposed minislot allocation based on RTP D-TDD architecture.

switching point, and the users having higher link gains to the minislots closer to the switching point. Since the time slots near the switching point of the reference cell have higher probability of having corresponding timeslots at the neighboring cells in opposite transmission direction, the timeslots near the switching point suffers from more CCI. That is, the time slots near the switching point suffer from relatively higher IBB and IMM from the neighboring cells. In the proposed algorithm, the loading of the traffic in each time frame is assumed to start from the far edges of the downlink time slots and the uplink time slots of each time frame, in order to avoid such interference as much as possible.

As an example, we consider the proposed TSA based on RTP D-TDD architecture in two cell environment in fig. 3. Since 3 minislots are defined in each time slot in the CTS period, the cell is divided into 3 mutually exclusive regions. In the figure, the numbers in each region represent the user locations. The shade for the background of the numbers represents the level of link gains, from white as the highest, to dark gray as the lowest level of link gains. As is shown in figure, the numbers with white background are allocated to the minislots near the switching point due to higher link gains. On the other hand, the numbers with gray background are allocated to the minislots farther from the switching point.

According to the above observations, we now present the proposed TSA based on RTP D-TDD architecture as follows.

1. Step1: Time partitioning

Let S and J denote the number of time slots in a frame and the number of neighboring cells, respectively. The time slot state information for the sth time slot of the reference cell is defined as $TSSI_{ref,s}$, and the time slot state information for the sth time slot of the jth neighboring cell is defined as $TSSI_{j,s}$ Time slot state information is encoded by -1, 1 or 0, according to downlink, uplink, and unassigned, respectively. Then the CTS period in the reference cell can be found by the following procedure.

```
for ( s = 1 : S ), do
    flag = 0
    for ( j = 1 : J ), do
        if TSSI_ref,s · TSSI_j,s == -1,
            flag = 1
        end if
    end for
    if flag ≠ 0,
        the sth time slot is included in the CTS period.
    end if
end for
```

We then divide each timeslot included in the CTS period into a certain number of minislots. Since the CTS period in the reference cell includes both the downlink and the uplink timeslots, the sth timeslot included in the CTS period is then defined according to the type of link as

$$T_s^D = \{M_{s,1}^D, M_{s,2}^D, \ldots, M_{s,R}^D\}, \quad s \in \text{CTS period}, \tag{1}$$

or

$$T_s^U = \{M_{s,1}^U, M_{s,2}^U, \ldots, M_{s,R}^U\}, \quad s \in \text{CTS period}, \tag{2}$$

where $M_{s,r}^D$ is the rth minislot in the sth downlink time slot, R denotes the number of minislots defined in CTS timeslot. The notations with superscript U imply the corresponding parameters for the uplink.

2. Step2: Region partitioning

Let (x_k, y_k) define the location of the kth user. Then, the users in the reference cell are partitioned according to their locations into one of R regions in the cell. Note that R is the same as the number of minislots in the CTS timeslot. The set of users located in the rth region is then represented as

$$U_r = \{k \mid (x_k, y_k) \in \text{region } r\}, \quad r = 1, 2, \ldots, R. \tag{3}$$

3. Step3: Link gain calculation

The next step in the proposed TSA is to evaluate the communication channel for each user according to the CINR estimate. We define a link gain function of the communication channel for the each user as

$$G_{r,k} \triangleq H_{r,k}^2 - PL_{r,k} - \hat{\sigma}_{I,r,k}^2 - \sigma_{N,r,k}^2 \text{ (dB)}, \quad k = 1, 2, \ldots, |U_r| \text{ and } r = 1, 2, \ldots, R, \tag{4}$$

where $PL_{r,k}$ represents the pathloss of the kth user in the rth region and $\hat{\sigma}_{I,r,k}^2$ denotes the estimated power of the interference to the kth user in the rth region, $|U_r|$ denotes the number of users in region r, and

$$H_{r,k} = \sqrt{\frac{1}{N} \cdot \sum_{n=1}^{N} |H_{r,k,n}|^2}, \tag{5}$$

where $H_{r,k,n}$ represents the frequency response of the nth subcarrier for the kth user in the rth region, and N is the total number of subcarriers. Here the pathloss, $PL_{r,k}$ is defined by

$$PL_{r,k} = PL(d_0) + 10\gamma \log_{10}\left(\frac{d_{r,k}}{d_0}\right) + X_\sigma \text{ (dB)}, \tag{6}$$

where d_0 represents a reference distance, and $d_{r,k}$ is the distance between the BS and the kth user, γ is the pathloss exponent, and X_σ represents a lognormal distributed random variable for shadow fading with standard deviation, [6]. The interference power for the kth user in the rth region is estimated as

$$\hat{\sigma}^2_{I,r,k}=(1-\varepsilon)\cdot\sum_{j=1}^{J}\delta_j\cdot\sigma^2_{(I|j),r,k}$$
$$\text{where } \delta_j=\begin{cases}1, & \text{if } TSSI_j\neq TSSI_{ref}\\ 0, & \text{otherwise}\end{cases}, \quad (7)$$

and where $\sigma^2_{(I|j),r,k}$ denotes the interference power from the jth neighboring cell, and ε represents the estimation error.

When the above procedure is repeated for all the users in each region we finally get the lists of link gains for the downlink and those for the uplink as follows;

$$G_r^D=\{G_{r,k}^D\}=\{G_{r,1}^D,G_{r,2}^D,\dots,G_{r,|U_r|}^D\}, \quad (8)$$

and

$$G_r^U=\{G_{r,k}^U\}=\{G_{r,1}^U,G_{r,2}^U,\dots,G_{r,|U_r|}^U\}. \quad (9)$$

4. Step4: TSA based on RTP D-TDD architecture

The final step is to allocate time slots to the users in each region so that the inter-cell interference can be minimized. It is assumed that the BS has an estimate of the total amount of downlink traffic, so the indices of the starting time slots for the actual traffic loading for the downlink time slots and the uplink time slots, S_f^D and S_f^U, have been calculated. We also define S^D and S^U to denote the number of downlink slots in the CTS period and the number of uplink slots in the CTS period, respectively.

Downlink TSA:

```
initialization : U_r = {1,2,...,|U_r|}
for r = 1 : R, do
  while ({G_{r,k}} ≠ null, and minislots remain), do
    s = s_f^D
    k̃ = arg max_k {G_{r,k}}
    while (k̃ not assigned to any minislot), do
      if s < (s_f^D − S^D + 1), break;
      else if M_{s,r}^D is unassigned,
        k̃ is assigned to M_{s,r}^D.
        update that M_{s,r}^D is assigned.
        U_r = U_r − {k̃}
      else, s = s − 1
    end while
    {G_{r,k}} = {G_{r,k}} − G_{r,k̃}
  end while
  if (U_r ≠ null, and non-CTS time slots remain),
    Assign the non-CTS time slots randomly to the users in U_r.
    update the time slot assignment.
  end if
end for
```

Uplink TSA:

The uplink TSA follows basically same procedure as the downlink TSA except that the parameters are taken from the uplink estimates for the kth user in the rth region.

For the performance evaluation, we utilize the CINR outage probability. To define the average CINR outage probability, we first define the CINR for the nth subcarrier of the kth user as

$$CINR_{k,n}=\frac{C_{k,n}}{\sum_{j=1}^{J}I_{j,k,n}+N_{k,n}}, \quad (10)$$

where $C_{k,n}$ denotes the power of the nth subcarrier in the received signal for the kth user, $I_{j,k,n}$ denotes the interference from the jth neighboring cell, and $N_{k,n}$ represents the noise power. Then, the CINR outage probability of the nth subcarrier for the kth user, $P_{OUT,k,n}(Th)$, is defined as the probability that the CINR of a certain subcarrier is less than a given hreshold, Th., is defined as

표 1. 모의실험 파라미터
Table 1. Systems parameters.

Number of cells	7
Cell radius	1000m
Transmission power (BS, MS)	43dBm, 23dBm
Number of time slots in a frame	14
Number of minislots per time slot (= number of regions in a cell)	3
Number of subcarriers in OFDM	128
Bandwidth of a subcarrier	10kHz
Frequency reuse factor	1
Pathloss exponent	4
Shadowing effect	8dB

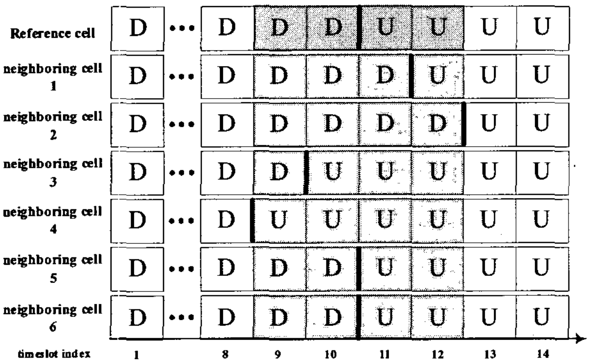

그림. 4. 제 1 시나리오: 7개 셀 환경에서 제 1 시나리오에 따른 시간 슬롯 상태 정보
Fig. 4. Scenario1: Time slot state information for scenario1 under 7-cell environment

$$P_{OUT,k,n}(Th) = \frac{1}{L}\cdot\sum_{l=1}^{L}\delta_{k,n,l}, \tag{11}$$

$$\text{where } \delta_{k,n,l} = \begin{cases} 1, & \text{if } CINR_{k,n,l} < Th \\ 0, & \text{otherwise} \end{cases}$$

and where L denotes the number of time samples to take the average.

Now the average CINR outage probability for the kth user, $P_{OUT,k}(Th)$, is defined as

$$P_{OUT,k}(Th) = \frac{1}{|S|}\sum_{n\in S} P_{OUT,k,n}(Th), \tag{12}$$

where S denotes a certain set of subcarriers of the kth user.

In this paper, the average CINR outage probability for each user is calculated over the CTS period, including both the downlink timeslots and the uplink

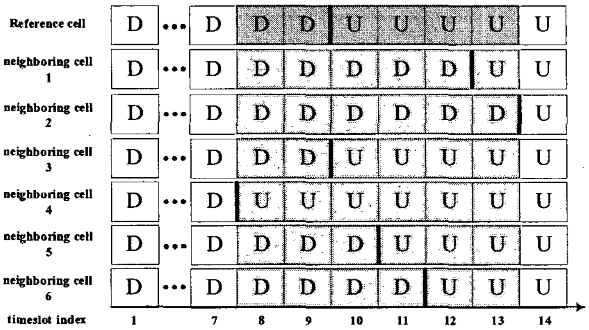

그림. 5. 제 2 시나리오: 7개 셀 환경에서 제 2 시나리오에 따른 시간 슬롯 상태 정보
Fig. 5. Scenario2: Time slot state information for scenario2 under 7-cell environment.

timeslots. So the set S in this paper is defined as the set of time slots in the CTS period.

Ⅳ. Performance Evaluation

The performance of the proposed TSA based on the RTP D-TDD architecture is evaluated using MATLAB under Pentium-IV personal computers. A random frequency hopping OFDMA is considered as the multiple access scheme and the transmission power for each subcarrier is assumed to be equal. The simulation assumes a 7-cell environment with 150 users in each cell. The center cell is designated as the reference cell. User locations in each cell are

표 2. 제 2 시나리오에서 수율 및 대역폭 효율 비교
Table 2. Comparisons in throughput and bandwidth efficiency for scenario2.

	Uniform		Non-uniform	
	throughput [Mbps]	Bandwidth efficiency [bps/Hz]	throughput [Mbps]	Bandwidth efficiency [bps/Hz]
TSA based on path gain	1.36	2.11	1.23	1.94
TSA based on location	1.80	2.82	1.74	2.72
TSA based on RTP D-TDD	2.08	3.25	2.01	3.09

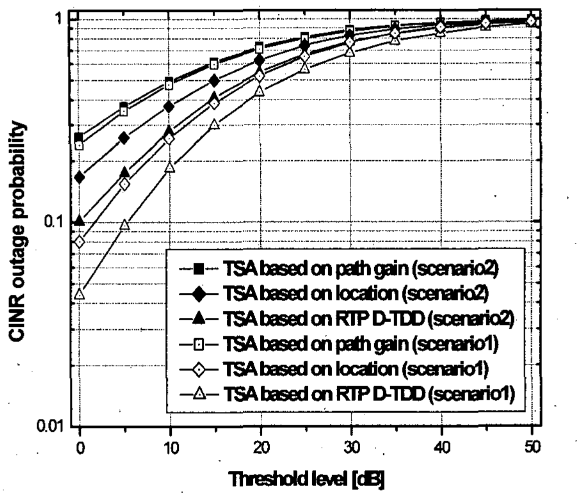

그림. 6. 제 1 및 제 2 시나리오에서 전방향 안테나를 사용한 경우 CINR outage 확률의 비교.

Fig. 6. Comparison of the CINR outage probabilities under the two scenarios with omnidirectional antenna

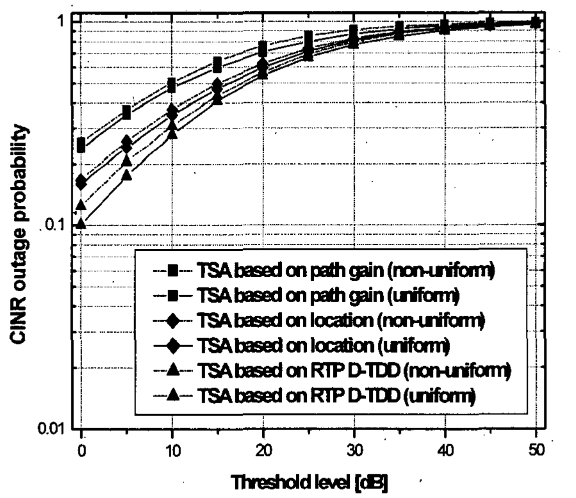

그림. 7. 제 2 시나리오에서 전방향 안테나를 사용한 경우 트래픽 환경에 따른 CINR outage 확률 비교.

Fig. 7. Comparison of the CINR outage probabilities under various traffic conditions for scenario2 with omnidirectional antenna

assumed to be uniformly distributed, but for the reference cell, both uniform and non-uniform distributions of user locations are investigated. The simulation was performed under the multipath fading channel described in Pedestrian A model in [7]. It is also assumed that a time slot consists of 6 symbols, so that 3 or 6 separate regions can be defined in each cell. Table 1 summarizes the system parameters in detail. In order to investigate the possibility of varying conditions in CTS regions, the evaluation has been done in two different scenarios, the time slot state information of which are as described in fig. 4 and fig. 5, separately. In the figures, the CTS periods of the reference cell are represented as the shaded area.

In the simulation, the proposed TSA based on RTP D-TDD architecture is compared with two conventional TSA schemes, the TSA based on path gain[4] and the TSA based on location[5].

In fig. 6, the CINR outage probabilities of the proposed algorithm have been compared with those of two conventional algorithms. Using either scenario1 or scenario2, the proposed TSA based on RTP D-TDD outperforms the conventional algorithms. As shown in the figure, the threshold level of the proposed TSA is about 4dB higher than that of the TSA based on location scheme at the same CINR outage probability. This results from the extended distances between the receiver in the reference cell and the interfering transmitters in the neighboring cells by applying the RTP D-TDD system. Besides, the influence of the CCI is further optimized by assigning minislots nearer the switching point to the users having higher link gains in the proposed TSA.

Note that for all the TSA schemes, the performance for scenario1 is better than the performance for scenario2, which shows the influence from the characteristics of CTSs. That is, since the scenario2 has 2 more time slots in the CTS period than the scenario1, it gets more CCI from neighboring BSs, so ends up with higher CINR outage probability. In fact, the length of the CTS period can be as long as the full length of TDD time frame, which implies that better performance in CTS period is critical to the overall system performance.

Fig.7 describes the CINR outage probabilities under various TSA schemes under different traffic conditions. Here, scenario2 has been considered for the performance evaluation. The 'non-uniform' traffic model represents the traffic condition when 50% of

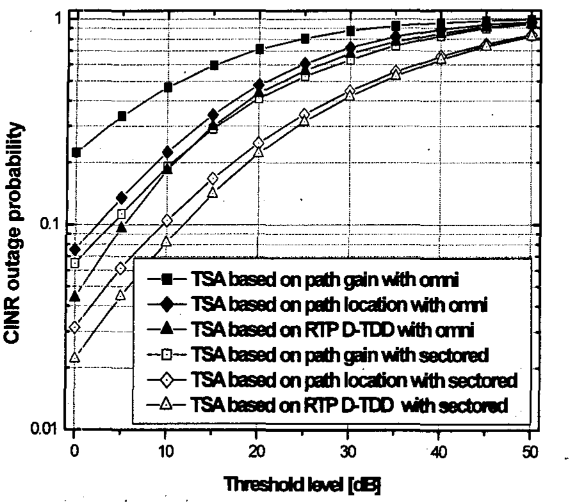

그림. 8. 제 1 시나리오에서 안테나 종류에 따른 CINR outage 확률 비교.

Fig. 8. Comparison of the CINR outage probabilities under scenario1 according to the types of antennas.

the total traffic is concentrated in one specific region in the reference cell and the remain traffic is uniformly distributed to the rest of the regions. Even under the non-uniform traffic distribution, the proposed TSA based on RTP D-TDD architecture outperforms the conventional TSA schemes.

In table 2, the average throughput and the bandwidth efficiency in CTS period are evaluated under different traffic conditions with scenario2. For the performance evaluation, we have applied an adaptive modulation using M-quadrature amplitude modulation (QAM) according to [8]. The non-uniform traffic is as defined in fig.7, and it is assumed that the BS operates with the omnidirectional antenna. Under uniform traffic condition, the bandwidth efficiency of the TSA based on RTP D-TDD is 1.14bps/Hz higher than that of the TSA based on path gain, and 0.43bps/Hz higher than that of the TSA based on location with uniform traffic condition. And under non-uniform traffic condition, the proposed TSA has 1.15bps/Hz and 0.37bps/Hz higher bandwidth efficiency than the TSA based on path gain and the TSA based on the location, respectively. Although the average throughput and the bandwidth efficiency for three algorithms are all reduced for non-uniform traffic condition, the proposed TSA based on RTP D-TDD still outperforms the conventional schemes by effectively reducing the CCI.

In order to investigate the possible combination with different types of antenna, the CINR outage probabilities according to different type of antennas under scenario1 are evaluated in fig. 8. By applying the sectored antenna, the CINR outage probabilities of all three algorithms has been improved. Note that the performance of the proposed TSA scheme is better than the others. In the TSA based on the RTP D-TDD architecture, it is assumed that each region corresponds to a mutually exclusive sector in the three sector cellular system. As is shown in the figure, with 120 degree sectored antenna, the threshold level of the proposed TSA is about 2dB higher than that of the TSA based on location scheme when the CINR outage probability is 0.05. Note that the whole bandwidth of the total subcarriers can be allocated to the users in each sector in the proposed TSA, whereas only one thirds of the total number of subcarriers is assigned to the users in each sector in the other TSA schemes. Therefore, the performance gain of the proposed TSA increases by fully utilized spectral diversity.

V. Conclusion

In this paper, we have proposed the RTP D-TDD architecture for OFDM systems, and a robust TSA based on the architecture, in order to mitigate the CCI in the CTS period. In the RTP D-TDD architecture, a time slot in the CTS period is divided into several minislots, and each cell is accordingly divided into as many regions. With the principle that the minislots in the CTS period is exclusively allocated to the users in the each corresponding region, the CCI in the CTS period is mitigated. On top of such architecture, a robust TSA scheme has been proposed in order to minimize that CINR outage probability in the CTS period, and thus increasing the throughput. By the computer simulation, the proposed TSA based on the RTP D-TDD architecture has been proved to outperform other conventional TSA schemes with regards to the CINR outage probability and the bandwidth efficiency.

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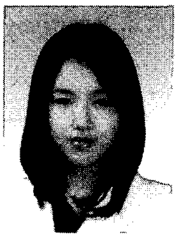
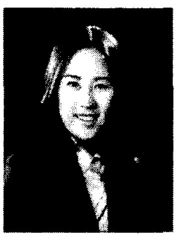
저 자 소 개



김 미 란(학생회원)
2005년 이화여자대학교 정보통신학과 학사 졸업.
2006년~현재 이화여자대학교 정보통신학과 석사과정.
<주관심분야 : hybrid division duplexing, OFDMA resource allocation, time slot allocation in TDD systems>



정 희 정(학생회원)
2004년 이화여자대학교 정보통신학과 학사 졸업.
2006년 이화여자대학교 정보통신학과 석사 졸업.
2006년~현재 삼성전자 무선사업부.
<주관심분야 : hybrid division duplexing, OFDMA resource allocation, time slot allocation in TDD systems>

김 낙 명(정회원)
1980년 서울대학교 전자공학과 학사 졸업.
1982년 KAIST 전기 및 전자공학과 석사 졸업.
1990년 미국 Cornell University 전기공학과 박사 졸업.
1990년~1996년 LG 정보통신(주) 책임연구원.
1996년~현재 이화여자대학교 공과대학 전자정보통신학과 부교수.
<주관심분야 : 4G mobile communications, MIMO-OFDM systems, cognitive radio, hybrid multiple access technologies, cross-layer optimization>