무선 멀티미디어 서비스를 위한 서브채널 상태 추정과 스케줄링

Subchannel State Estimation and Scheduling for Wireless Multimedia Services

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요약

차세대 무선 망 시스템에서는 멀티미디어 서비스가 당연히 요구되며 그리고 경제적인 패킷 데이터 전송은 필수적이다. 이러한 점에서, OFDMA (WiBro) 시스템에서는 다양한 트래픽 클라스를 최적하게 제어할 수 있는 적응적 자원관리 방법이 요구된다. 본 논문은 과거의 서브 채널 상태 정보를 기반으로 최근 서브 채널 상태를 예측하는 알고리즘을 개발하였고 이 방법을 이용하여 또한 다운링크의 멀티미디어 트래픽을 효과적으로 제어하는 스케줄링 알고리즘을 개발하였다.

Abstract

For the next generation wireless systems, multimedia services will be highly demanded and needed to transmit the cost-efficient packet data. With this regard, the adaptive resource management methods are preferable to optimally control the various traffic classes in OFDMA (WiBro) systems. We have developed a sub-channel state prediction method based on the past sub-channel state dependency. Using the method, we are developed a scheduling algorithm that can efficiently control multimedia traffic downlink transmissions.

I. 서 론

Future wireless systems are being evolved toward 4th generation mobile systems. Recently IEEE802.16e has been finalized to the standard documents for wireless metropolitan area networks(WirelessMAN)[5]. In this standard, orthogonal frequency division multiplexing (OFDM) based air interface was chosen as a base line physical layer technique. Among various multiple access methods for OFDM, orthogonal frequency division multiple access (OFDMA) is recognized as one of promising techniques to support multimedia services in broadband wireless systems, such as WiBro. Sub-carriers and symbol duration of OFDMA can be efficiently allocated with the traffic types and QoS requirements. Therefore, if the channel state would be known by the access point, then the very high system performance can be achieved from the optimal sub-channel and symbol block allocations [2]. However, OFDMA system may cause the system complexity and message overhead due to the synchronization of the communication systems [2,3,4].

We have developed the sub-channel state

prediction method that forecasts the future sub-channel state in terms of each MT's sub-channel fading characteristics. The prediction scheme is based on the short time lag dependent time-series of the fading channel. In this method, we introduce a parameter T, the prediction interval. In the studied fixed wireless fading environment of this paper, we have tested the affect of T in terms of the prediction accuracy rate comparisons with T interval increases. In the simulation, we compare the prediction accuracy rate at the various T intervals for the four different sub-channel allocation schemes. The result shows that the proposed method is outperformed the random allocation and better than the simple adaptive allocation. Using this prediction algorithm, we also develop scheduling algorithm.

In the following section, we present sub-channel state prediction and scheduling algorithms. Simulation results are shown in section 3. Conclusion and future work are devoted in section 4.

II. Algorithm

We introduce the method to predict sub-channel state for OFDMA systems. [Fig. 1] shows the frequency-time slotted channel structure of OFDMA system. In this figure, parameter T is represented the interval of the sub-channel state prediction. Every T cycles, the sub-channel allocation method modifies transmission pattern embedding by wireless fading signal variances.

The wireless channel is modeled from frequency-selective Rayleigh faded signal[1]. For simplicity, threshold gain of the channel is used to define channel state G (good) or B (bad). The sub-channel state prediction method is to forecast the future channel state from the past channel states. For this purpose, we have developed two methods. The first one is to use past time lag dependent channel gain estimation method. The following Eq.1 shows the scheme.

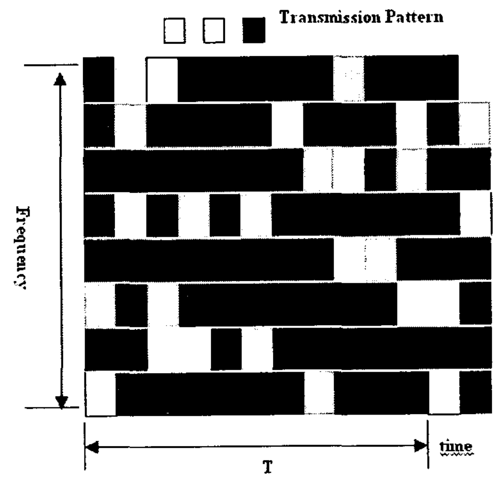

Figure 1. Channel Structure of OFDMA

$$\hat{z}(n-k) = a^{k}(n) \cdot z(n) \qquad (1)$$

where z(n) is current channel gain. a(n) is time-varying weighting value, and it should be changed according to the prediction accuracy. z^(n+k) shows the predicted channel gain at k-step ahead. Determination of a(n) is implemented using least mean square criterion.

Second method is to use the averaging G or B state duration. The prediction criterion is the state duration. Recently switched state can be longer being the same state probabilistically. But if the state duration is longer than the state average,then it would be switched to the other within the short time. This can be represented as follows,

$$y_i^{(G)}(n) = \beta \cdot w_i^{(G)}(n) + (1-\beta) \cdot z_i^{(G)}(n-1) \qquad (2)$$

where z represents the sub-channel gain at event $n-1$, and y is the value in which the transmitter uses to predict the state of the sub-channel i for the next event n. Eq.(2) means that the average duration of the sub-channel state G is added by the most recently available sub-channel gain z(n-1).

The two proposed methods select sub-channels and symbol blocks at the T period in terms of the largest channel gain predicted. We have tested two more methods. One of them is random allocation method that selects sub-channels at every T period using uniform random distribution of the selection probability of the sub-channels. The second is a simple adaptive allocation method that selects sub-channels at every T period according to the previously selected sub-channel's gain. Sub-channels with larger gains in the previous time will have more chances being selected.

Using the predicted sub-channel information, a newly developed scheduling algorithm can efficiently control multimedia traffic downlink transmission for the fixed wireless FH-OFDMA systems. Varying time scales for the future sub-channel state prediction also can be possible from the over 10ms to 1ms intervals. In this manner, the algorithm can better handle both the fairness problem and improving throughput.

The scheduling algorithm uses the sub-channel state prediction scheme before deciding the traffic transmission rates according to the QoS requirement. The result of sub-channel state prediction provides the best and worst channel states in terms of each MT's sub-channel fading characteristics. With the predicted channel information, the scheduling algorithm easily achieves user diversity in the given spectrum. Besides, this predicted information, the scheduler uses weighted fairness factor to balance the fairness and throughput issues.

III. Simulation

We set the simulation parameters for OFDMA system in the Table 1. Fixed mobile, downlink channel, and just one mobile terminal are considered in the simulation. Simulation runs a number of times with OFDMA symbol time 500ms length, and the results are averaged.

The prediction accuracy rate is calculated from comparison of the predicted and real sub-channel states. For every sub-channel, the sub-channel state is predicted and the real state is compared at every T interval.

Table 1. OFDMA system parameters

Number of sub-channels	64
Cyclic prefix	8
Channel characterization	Frequency selective Rayleigh fading
OFDM symbol duration	100 μsec

In [Fig. 2], we show the simulation result in the case of T=10ms and B={1,2,,5}. B represents the number of allocated sub-channels at one symbol time. As we can see, the increasing B is not affected the prediction accuracy rate(y-axis) for every methods. Also comparing the prediction accuracy rate reveals that LMS based prediction is the best method and random case is the worst one.

[Fig. 3] shows that increasing T intervals causes the prediction accuracy decreases in every method except the random case. Until T=10ms, we can observe the prediction accuracy rate is over 90% for the three methods. [Fig. 3] result implies that the extending T interval introduces more fluctuation on the faded channels. This accuracy comparison also shows that LMS based method is the best than the other methods before 10ms.

In the following simulation results, we show the transmission rate changes of ten mobile terminals in terms of applying the weighted fairness factor. [Fig. 4] uses the weighted fairness factor and [Fig. 5] does not. We can observe that the accumulated transmission rate for each mobile is converged toward the mean rate in [Fig 4]. The total simulation time is 200 ms and prediction interval is 1 ms with random packet sizes and arrival intervals for the ten data services. This convergence is showing fairness acheivement due to the weighted fairness factor and the prediction.

We are continuing working to develop a more robust channel estimation method, and ultimately integrating it with more efficient multimedia traffic scheduler in the broadband wireless environment.

Ⅳ. Conclusion

We show that the possibility of sub-channel state prediction in fixed mobile with frequency-selective faded channel of OFDMA systems. This result needs to be further investigated in the more time and frequency varying wireless mobile environment. We are currently doing work on the development of more robust channel state estimation method. Ultimately object of our work will be integrating optimal multimedia-traffic scheduling algorithm with work presented in this paper. This object can be achieved by the design of less overhead and less complex broadband wireless system using the cost-efficient and fairness-vs-throughput optimally balanced algorithm.

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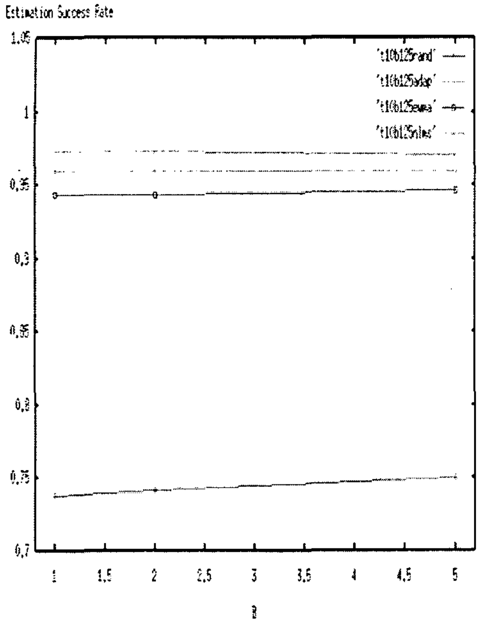

Figure 2. Prediction accuracy rate comparison with T=10ms and B allocation variables

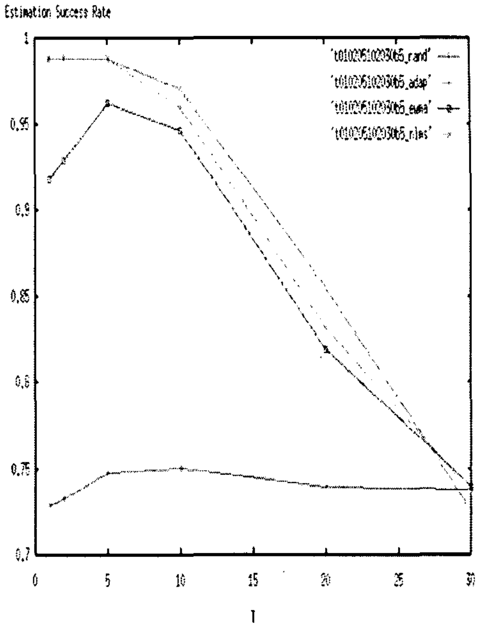

Figure 3. Prediction accuracy rate comparison with T intervals

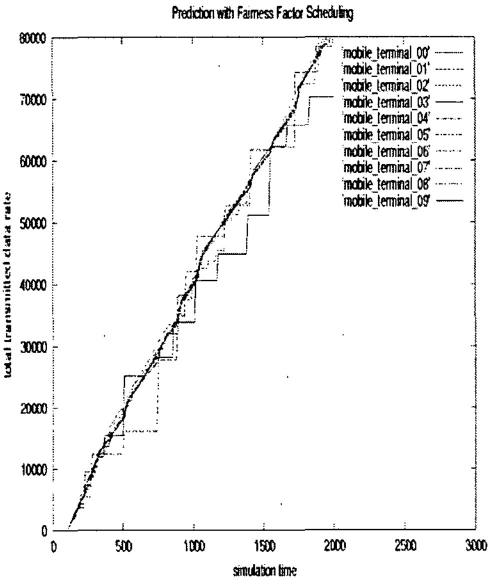

Figure 4. Accumulated transmission rate applied prediction with weighted fairness factor scheduling

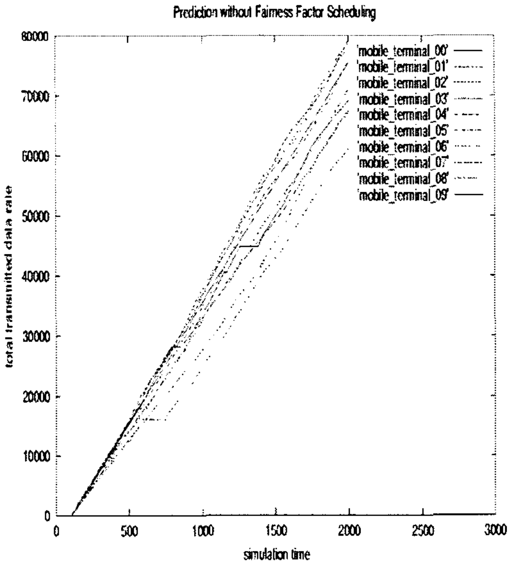

Figure 5. Accumulated transmission rate applied prediction without weighted fairness factor scheduling