Dynamic Random Channel Allocation Scheme For Supporting Qos In Hiperlan/2

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Abstract:

The MAC protocol of HIPERLAN/2 is based on TDMA/TDD and AP (Access Point) can dynamically allocate the number of RCHs (Random CHannels). We propose a dynamic random channel allocation scheme improved by limiting the number of minimum RCHs. On a simulated scenario adopted practical Internet traffic, the proposed scheme is shown to achieve over 19% lower delay than previously studied algorithm. This study will be a first step towards designing scope of RCHs for high-performance wireless packet network

Keywords: HIPERLAN/2, MAC frame, RCH, Dynamic Random Channel Allocation Scheme

1. INTRODUCTION

The ETSI BRAN decided HIPERLAN/2 (HIgh PErformance Radio Local Area Network Type 2) [1, 2, 3] which is made by the ETSI BRAN project as standard to compose broadband wireless access network. HIPERLAN/2 can support high date rates up to 54Mbps using OFDM (Orthogonal Frequency Division Multiplexing) in 5 GHz, same as IEEE 802.11a. Therefore, HIPERLAN/2 is suitable to support multimedia application service in wired and wireless environment.

On the AP side, HIPERLAN/2 basic protocol consists of CL (Convergence Layer), DLC (Data Link Control) layer, PHY(Physical) layer. The DLC layer consists of the RLC (Radio Link Control) function, EC (Error Control) function and MAC (Media Access Control) function.

The PHY layer of HIPERLAN/2 is based on the modulation scheme OFDM. In order to improve the radio link capability due to different interference situations and distance of MTs (Mobile Terminals) to the AP, a multi-rate PHY layer is applied, where the "appropriate" mode will be selected by a link adaptation scheme. The data rate raging from 6 Mbps to 54 Mbps can be varied by using various signal alphabets for modulation the OFDM sub-carriers and by applying different puncturing patterns to a mother convolution code. BPSK, QPSK, 16QAM are used and mandatory modulation format [4].

The MAC layer shows a remarkable contrast between IEEE 802.11a and HIPERLAN/2. While the MAC protocol of IEEE 802.11a is based on CSMA/CA, HIPERLAN/2 guarantees QoS (Quality-of-Service) required in ATM and IP network [5] by using Dynamic TDMA/TDD (Dynamic Time Division Multiple Access/Time Division Duplex) [6]. HIPERLAN/2 plans to interwork mobile terminal and wired broadband network, whereas IEEE 802.11 is limited to fixed network based on Ethernet [7].

Not CSMA/CA, due to the MAC protocol of HIPERLAN/2 is based on a Dynamic TDMA/TDD, HIPERLAN/2 can support QoS, high-speed transmission, security, mobility, automatic frequency allocation, and power saving function. Therefore, it is possible to transmit simultaneously a various kind of data such as image, voice and video.

The structure of this paper is as follows. We describe the MAC frame based on TDMA/TDD and previous random channel allocation scheme of HIPERLAN/2 in section 2. And we propose improved dynamic random channel allocation scheme in section 3. We evaluate performance using computer simulation in section 4 and conclude this paper in section 5.

2. MAC FRAME AND RANDOM ACCESS ALLOCATION SCHEME

The HIPERLAN/2 MAC that resides at the AP controls all the transmissions over the wireless media [8]. This includes uplink transmissions from MTs to the AP, downlink transmission from the AP to the MTs, and direct transmission among the MTs. Direct transmission is mandatory for the residential or ad hoc configuration. Therefore, the MAC deploys TDMA/TDD. The channel is structured into MAC

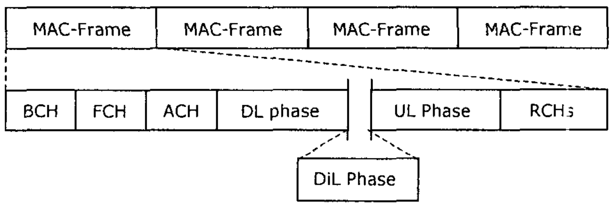

Fig. 1. MAC Frame Structure

frame as shown in Fig. 1. The MAC frame has a fixed duration of 2ms. Each MAC frame starts with the BCH (Broadcast CHannel) duration.

The MAC frame consists of BCH duration, FCH (Frame control CHannel) duration, ACH (Access feedback CHannel) duration and at least one RCH (Random CHannel) duration. If there is transmission between the AP and the MTs, The DL (Downlink) and/or UL (Uplink) phase are included in the MAC frame. If there is transmission among the MTs, the DiL (Direct Link) phase is also included. The BCH duration is fixed. The duration of the FCH, DL, DiL, and UL phase and the number of RCHs are dynamically determined by the AP[9].

Accessing the RCH is as follows. The access to RCHs shall be controlled by a contention window CW_a maintained by each MT. The contention window

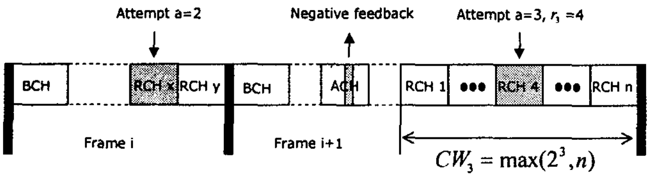

Fig. 2. An Example of the next access RCH $r_{\#a+1}$ within the current MAC Frame

shall be derived from the number a is the number of retransmission attempts made by the MT. For the first access attempt, a shall be set to 0. The size of the contention window, CW_a, is defined as follows, where n is the number of RCHs in the MAC frame where r_a is calculated [2]:

1) Initial Attempt:

$$a = 0,\ CW_0 = n$$

2) Retransmission:

$$a \geq 1,\ CW_a = \begin{cases} 256, & 2^n \geq 256 \\ 2^a, & n < 2^a \leq 256 \\ n, & n \geq 2^a \end{cases}$$

The RCH used for the a^{th} retransmission attempt including an initial transmission ($a = 0$) shall be chosen by a uniformly distributed random integer value r_a within the interval $[1, CW_a]$. The random number generator is not specified. The MT shall start counting r_a from the first RCH in the MAC frame, in which the ACH indicates the failure of the previous access attempt. In case of a equal to 0, the MT starts counting with the fist RCH in the current frame. The first RCH is specified by number '$r_a = 1$'. The RCH with number equal to r_a is the RCH that the MT shall access. The MT shall not access the RCH before its counter has reached the RCH with the number equal to r_a. After receiving the ACH with a positive feedback, shall be reset to 0.

AP scheduler controls composition of each MAC frame and the number of RCHs may vary frame to frame. Allocation of excessive RCHs may cause the squandering of radio resource and small RCHs compared to traffic load may generate many collision of access attempt, which affect longer access delay.

The previous scheme [10] showed an adaptive RCHs allocation algorithm considering results of users' access attempts within previous MAC frame. AP increases RCHs of next MAC frame as many as collided RCHs and decreases them by successful access attempts. When there are no access attempts in previous MAC frame, the AP reduces RCHs of upcoming frame by 1. The previous scheme updating the number of RCHs is given by

$$r(t+1) = r(t) + \alpha(N_f(t) - N_s(t))(1 - I_{idle}(t)) - I_{idle}(t)$$
(1)

where meanings of variables are as follows:

$r(t)$ number of allocated RCHs at MAC frame t;
α : weighting factor;
$N_f(t)$ number of collided RCHs at MAC frame t;
$N_s(t)$ number of successful RCHs at MAC frame t;
$I_{idle}(t)$ indication function of which value is 1 if there is no access attempt at MAC frame t; otherwise its value is 0.

The previous scheme limits the scope of allowable number of RCHs per MAC frame.

$$r(t+1) = \min\{\max\{r(t+1), 1\}, R_{MAX}\} \quad (2)$$

where R_{MAX} is maximum number of RCHs in one MAC frame, which constrains random access interval.

3. PROPOSED DYNAMIC RANDOM

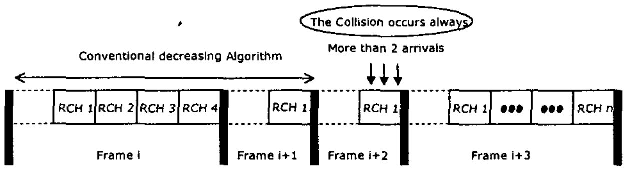

Fig. 3. When the number of minimum RCHs is 1, the collision occurs.

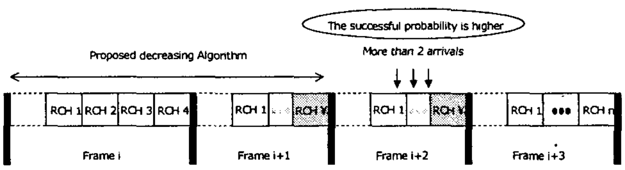

Fig. 4. The proposed dynamic random channel allocation scheme

CHANNEL ALLOCATION SCHEME

We propose dynamic random channel allocation scheme improved by limiting the number of minimum RCHs.

$$r(t+1) = r(t) + \alpha(N_f(t) - N_s(t))(1 - I_{idle}(t)) - I_{idle}(t)$$
$$r(t+1) = \min\{\max\{r(t+1), \beta\}, R_{MAX}\} \quad (3)$$

β : minimum factor

The number of minimum RCHs is varied within the interval $[\beta, R_{MAX}]$. The proposed scheme achieves high throughput and low delay by optimized minimum factor β.

The proposed scheme can prevent the following problem occurring in the previous scheme. When there are no access attempts in previous MAC frame, the AP reduces RCHs of upcoming frame by 1. In case of reducing the number of RCH by 1, if more than two MTs attempt channel access, access attempts collide and delay increases by waiting next frame. That is, according to setting the number of minimum RCH to 1, unnecessary delay increases. Fig. 3 shows that more than two arrivals collide in one RCH.

Fig. 4 shows the proposed dynamic random channel allocation scheme. AP decreases RCHs of the $(i+1)^{st}$ MAC frame according to result of the i^{th} MAC frame. By Equation (3), due to the number of RCHs decreases by β, the proposed scheme raises success probability about access attempts in the $(i+2)^{nd}$ MAC frame. That is, as it prevents collision at the $(i+1)^{st}$ frame, the proposed scheme improves resource utilization and reduces delay.

4. PERFORMANCE EVALUATION

We performed a remarkable computer simulation to evaluate the performance of proposed dynamic random channel allocation scheme. Most real world Internet traffic has characteristics of Ethernet traffic and batch arrival. Under this environment, we have used two performance measures. One is the average access delay and the other is the throughput.

Simulation model is as Table 1.

Table 1 Simulation Parameters

Parameter	Value
Frame Length	2 ms
The # of MAC frame	5×10^5
Arrival Dist.	Poisson Process
Batch Dist.	Geometric Dist.
Avg. Batch Size	10
Message Size Dist.	Ethernet Traffic

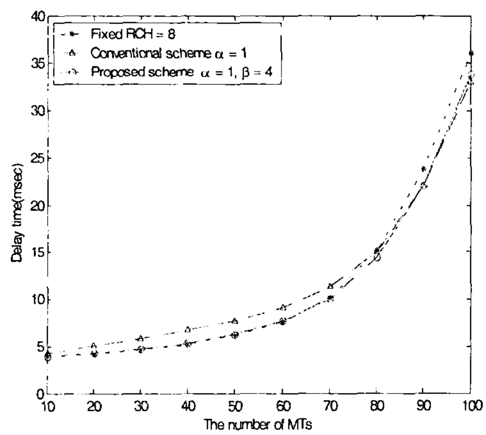

Fig. 5. Delay versus the number of MTs with fixed arrival rate

Fig. 5 shows delay versus the number of MTs at fixed arrival rate (λ =0.02). The proposed scheme has the merits which is fixed.

RCH scheme be got delay efficiency at light traffic and previous scheme is got it at heavy traffic. When the number of MT is below 80, proposed scheme using defined minimum factor shows 19% delay decrease at the maximum.

Fig. 6 shows throughput versus the number of MTs at fixed arrival rate. When is 4, we gets higher throughput than previous scheme. The throughput is defined as

$$Throughput = \frac{Total\ duration\ of\ used\ UL\ phase}{Total\ duration\ of\ allocation\ UL\ phase}$$

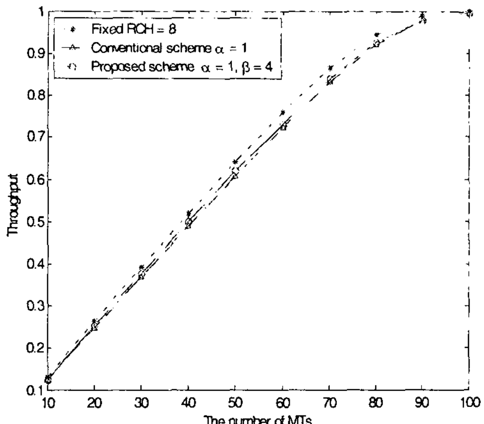

Fig. 6. Throughput versus the number of MTs with fixed arrival rate

The maximum value of throughput is 1 which means all allocated UL phase are used for transmission.

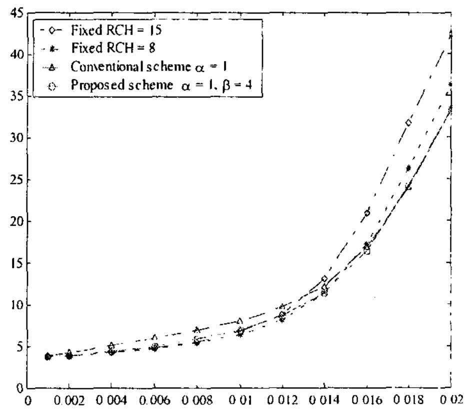

Fig. 7. Delay versus arrival rate with 100 MTs

Fig. 7 shows delay versus arrival rate at fixed number of MTs. Also, This result reveals that proposed scheme has the merits which fixed RCH scheme be got delay efficiency at light traffic and previous scheme is got it at heavy traffic. Then, We get 16% delay decrease than previous scheme and 8% than scheme using fixed RCH. When the traffic load occurs frequently, the scheme using fixed RCH has the high rate of increase. However our propose scheme which has adaptive random channel algorithm involved in previous schemes can reduce efficiently delay.

Fig. 8 shows delay versus arrival rate with 50 MTs. We are able to verify that unnecessary collisions frequently occur at light traffic, because RCH is decreased until 1. In this case, previous scheme cannot prevent delay increase on account of unnecessary collision. Whereas the proposed scheme is able to reduce the delay on the way constrained minimum RCH raises successful attempt probability.

Fig. 9 and 10 show delay versus arrival rate as various at a fixed number of MTs. We obtained thought simulation that optimal minimum factor β is between 3 and 5.

Therefore, changeable number of RCH needs to constrain the scope from 3, 4 and 5 to 31.

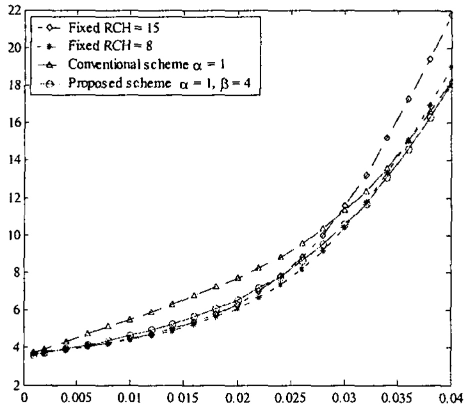

Fig. 8. Delay versus arrival rate with 50 MTs

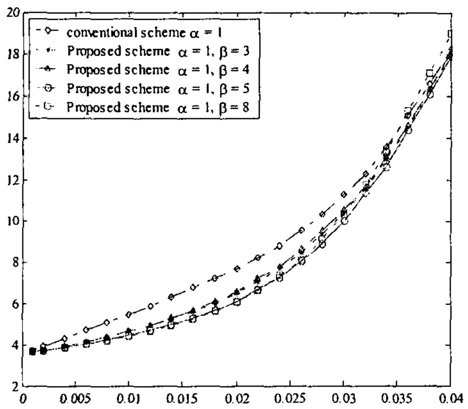

Fig. 9. Delay versus arrival rate with 100 MTs and various β

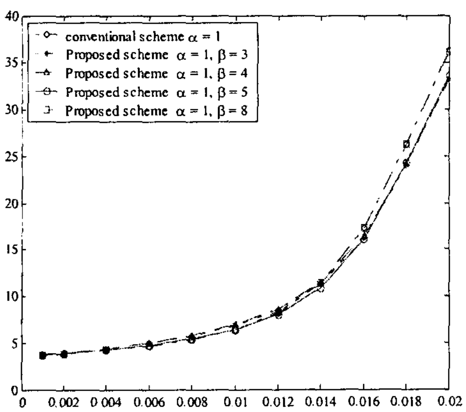

Fig. 10. Delay versus arrival rate with 100 MTs and various β

We simulated the proposed scheme in total MAC frame, contrary to the conventional schemes were evaluated in only RCH duration. Therefore, the output of simulation can be applied to practical HIPERLAN/2 implementation.

5. CONCLUSION

We proposed a dynamic random channel allocation scheme to minimize a waste of channel by limiting the number of minimum RCHs. The proposed scheme was performed under practical Internet traffic achieved high efficiency of radio resource and very short access delay. Besides, to satisfy system requirements for practical HIPERLAN/2 implementation, we performed computer simulation the proposed scheme in whole MAC frame. Therefore, the proposed scheme is helpful to decide the boundary of minimum RCHs

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