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Adaptive Resource Allocation for Video Stream Based on Video Stream Character and User Mobility in Wireless LAN

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SUMMARY In this paper, an adaptive resource allocation scheme for video stream based on video stream character and user mobility in wireless LAN is proposed. The proposed adaptive allocation scheme allocates the time slots according to the kind of the real-time or non real-time video stream, the required bit rate of video stream and user's mobility by each user. In the proposed system, when user requests the non real-time video stream and its dwell time is smaller than the service time of the video source, more time slots are allocated to the user. When user requests the non real-time video stream and its dwell time is larger than the service time of the source video, or when user requests the real-time video stream, minimum amount of the required time slots are allocated. The computer simulation results show that the proposed allocation scheme can achieve the better performance than the conventional allocation schemes which allocate the time slots only considering the required bit rate or user's dwell time.

key words: *radio resource management, radio agent, user mobility, dwell time, spot radio access*

1. Introduction

Realizing the dream of ubiquitous network, various radio access systems are required to use complementary. Wireless LAN (Local Area Networks) standard is the most broadband interfaces among many air interfaces. IEEE 802.11 a, b or g are assumed to replace the wired LAN to wireless in a home or an office environment. They have achieved 54Mbps although wireless WAN (Wide Area Network) has not achieved it yet. It enables users to connect to the Internet as well as to retrieve various kinds of video stream services such as VoIP (Voice over IP) or VoD (Video on Demand).

The wireless LAN has been considered to adapt to the other different situations recently. The hot spot service with wireless LAN has taken off at public spaces such as airport or cafe. CALM (Communication Air interface for Long and Medium range) [1], which is one of the new standard of ITS (Information Transport System), standardize the radio access system based on IEEE 802.11a.

Many technical challenges are required when users walk through or go through a wireless LAN access spot. Mobility management is one of the challenges and Mobile IP (Mobile Internet Protocol) [2] or SIP (Session Initiation Protocol) [3] is able to solve [4]. However, the restriction of user's dwell time is critical but not solved by these mobility management schemes. The dwell time is a period during which a user stays in a particular wireless LAN spot. If user walks through a spot with higher speed, it becomes smaller. Although mobility management is able to change the access network from wireless LAN to wireless WAN seamlessly, the wireless transmission rate decreases when user leaves out the wireless LAN access spot. It degrades the service quality of small dwell time users because the received data size at a wireless LAN spot is restricted by the small user dwell time. Therefore, a small dwell time user at wireless LAN spot has to be prioritized than a long dwell time user and allocating much radio resources to small dwell time users are required. Reference [5] has proposed data transmission method for spot communication system. The scheme controls transmitting data size according to the user dwell time. It is able to reduce the traffic load in the wired network. However, the received data size of small dwell time user becomes small because the scheme reduces the transmitting data size when the dwell of the user is small. To improve the received data size of the small dwell time user, the radio resource management considering user mobility is required.

The wireless channel is not only strictly band-limited but also impaired by the channel error due to the noises, interferences, fading, and shadowing. It is difficult to accommodate multiple video streams. IEEE 802.11e standard [6] enables resource management with IEEE 802.11 a, b or g. EDCA (Enhanced Distributed Channel Access), which is the extension of DCF (Distributed Coordination Function), categorizes video streams to four categories and gives the priority to them. However, criterion of the four priorities is not standardized at the IEEE and depends on implementation of vendors. The radio resource management scheme for mobile communication systems has considered [7], [8]. It is able to utilize the radio resource effectively and to satisfy the QoS (Quality of Service) requirements for various services. Reference [7] has proposed adaptive wireless transmission scheme for mobile communication system. The scheme controls wireless transmission format according to the required QoS parameters such as throughput, transmission delay and bit error rate. Reference [8] has proposed the cross-layer adaptation for video stream. The adaptation scheme selects time slots allocation and bit rate of video stream according to the wireless channel quality and error sensitivity of the video stream. It improves the PSNR (Peak-to-Signal and Noise Ratio) of the video stream. However,

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these conventional resource management schemes cannot be applied to the spot mobile communication systems because they have not considered how to allocate the radio resource according to the user mobility.

On the other hand, an each video stream source has different character, the instantaneousness or the required bit rate. From the point of instantaneousness, a video stream is identified to two types. Non real-time stream data is encoded beforehand and transferred to the user when a user requests. The user is able to download and store a future data of non real-time video stream at a terminal buffer when there are available network resources to transfer and a terminal buffer is large enough to store. This is because non real-time video stream was stored at the server previously. The real-time stream data such as VoIP is encoded and carried to a user immediately. The user is not able to receive and store a future data at a terminal buffer because it is processed instantaneously. From the point of the required bit rate, the required bit rate for each video stream differs. Considering the difference of instantaneousness from the point of user's mobility, when more radio resource is allocated to a user who requests non real-time stream, latency time to download non real-time stream reduces by buffering at a terminal buffer. This effect avoids the degradation of the service quality of a small dwell time user. Therefore, the priority of non real-time stream is required to be higher when small dwell time user request it in the wireless LAN spot.

We have proposed the adaptive wireless transmission scheme considering user's dwell time for spot access system [9]. The transmission scheme selects high-speed modulation format such as 64QAM (Quadrature Amplitude Modulation) when the dwell time of user is short. It can increase the received data size of the short dwell time user. It shows that considering the dwell time of users as QoS requirements improves the service quality of users in the spot communication system. The scheme allocates the radio resources only according to the dwell time of a user. However, the scheme does not consider the difference of the kinds of real-time or non real-time video stream and the required bit rate of video stream. When more radio resources are allocated than user requires to the real-time stream, it becomes the waste use of the radio resource because users are not able to store the future data of the real-time stream. On the other hand, when the allocated radio resources does not satisfy the required bit rate of the video stream, the transmission delay degrades the service quality of the received video stream. Therefore, the performance of the scheme degrades when user requests the various video streams of which the required bit rate and the kinds of real-time or non real-time differ.

In this paper, we propose a novel radio resource allocation scheme for video stream based on video stream character and user mobility in wireless LAN system. The proposed scheme allocates time slots according to the user mobility and the kinds of real-time or non real-time video stream as well as the required bit rate of the video stream. In the proposed scheme, service of a video stream is classified four categories by kinds of video stream and user mobility. When a small dwell time user requests non real-time stream, more time slots are allocated to the user.

In the following, Sect. 2 describes the system model and the proposed adaptive resource allocation scheme, and in Sect. 3, a computer simulation evaluates the performance of the proposed scheme. Section 4 concludes this paper.

2. System Description

2.1 Transmission Procedure of the Proposed Scheme

Figure 1 illustrates the block diagram of proposed resource allocation system for video stream service. The base stations are connected to the real-time stream source and non real-time stream source via the Internet through the Layer 7 router. When a user requests a data, the speedometer on a terminal estimates its movement speed. In the proposed transmission scheme, the terminal uploads its speed to the mobility estimator via an uplink. Mobility estimator equipped at the Layer 7 in the Layer 7 router estimates the user movement status, m (= 0 or 1), static or moving. If a user is estimated to go or walk through a wireless LAN spot from user speed, it is categorized as moving ($m = 1$). On the other hand, user is estimated to stay at the access spot till the service ends, user is categorized as static ($m = 0$). Table 1 describes the parameters of movement state, m, for each user. Then movement state, m, is sent to the radio agent [10]. Packet analyzer reads the required bit rate, β, the traffic category, γ, of video stream data. Table 2 describes the traffic category, γ. Traffic category, γ, distinguishes the kind of video stream. In the proposed scheme, two categories real-time and non real-time stream are prepared. Then the

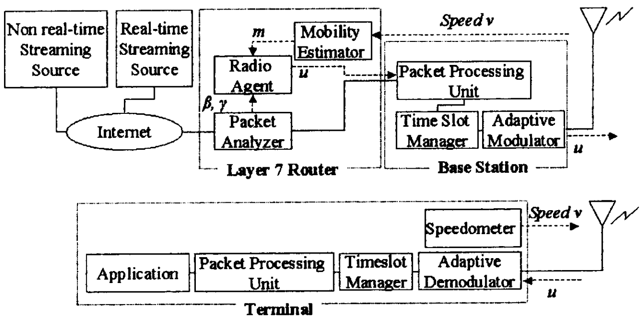


Fig. 1 The block diagram of the proposed system.

Table 1 User movement status m.

Movement status m	
0	Static user
1	Moving user

Table 2 Traffic category γ for stream data.

Traffic Category γ	
0	Real-time streaming
1	Non real-time streaming

packet analyzer sends β and γ to the radio agent. Based on m, β and γ, the radio agent allocates time slots, u, to the user and passes them to the packet processing unit by means of the header of each transmitted packet. At the radio base station, according to the allocated number of time slots attached to the packet header, the data is modulated a RF carrier at adaptive modulator and is sent to the terminals in the allocated slots. The terminal demodulates the received data and the packet processing unit reconstruct the original data from received packets.

2.2 Proposed Algorithm

2.2.1 Allocation Policy

In this section, we describe the resource allocation policy of the proposed adaptive resource allocation scheme. This allocation scheme uses dynamic TDM (Time Division Multiplexing), which is able to allocate U time slots arbitrarily to an each user. Whitecap2 [11], which is based on the provisional plans of the IEEE 802.11e, adopts similar dynamic TDM. In the proposed algorithm, buffer size of the terminal is assumed large enough to accommodate the non real-time video stream. The proposed algorithm introduces the four service categories from user mobility, m, and traffic category, γ. Table 3 shows the classification of service class, S_c. u' denotes the required time slots to transfer an each video source without service degradation. For example, if user requests VoIP of 64 [kbps], u' are calculated to satisfy transferring at 64 [kbps]. Service is identified to the Class 0 or Class 1 when real-time video stream is requested by static or moving user respectively. Service is identified to the Class 2 or Class 3 when static or moving user requests non real-time video stream respectively.

The proposed algorithm allocates u time slots according to the service class, S_c. At the Class 0 and Class 1 service, slot allocation is required to satisfy the minimum number of time slots ($u = 1 \times u'$) regardless of user mobility. This is because a future data of real-time video stream is not able to transfer and store at a terminal buffer depending on its instantaneously. At the Class 2 service, time slots are allocated to satisfy the minimum number of the required time slots ($u = 1 \times u'$) although latency time to finish transferring data improves when more time slots are allocated. This is because static user is able to retrieve the entire video stream at the wireless LAN spot. At the Class 3 service, the service quality improves when many time slots are allocated to the moving user at the wireless LAN access spot. This is because the user is able to download and store a future data when there are available radio resources to transfer. Therefore, when there are many available time slots, time slots are allocated as large as possible according to the resource coefficient α. Resource coefficient α is calculated from the available time slots. If there is a large available time slots, α becomes $\alpha > 0$.

Table 3 Classification of service class S_c.

Service Class S_c	m	γ		Slot Allocation: u (u':Required time slots)
Class 0 ($S_c = 0$)	0	0	Real time stream with static user	$u = 1 \times u'$
Class 1 ($S_c = 1$)	1		Real time stream with moving user	$u = 1 \times u'$
Class 2 ($S_c = 2$)	0	1	Non-real time stream with static user	$u = 1 \times u'$
Class 3 ($S_c = 3$)	1		Non-real time stream with moving user	$u = (\alpha + 1) \times u'$ (α:resource coefficient)

2.2.2 The Procedure of the Proposed Algorithm

In this section, the procedure of the proposed algorithm is described. Assuming that n users request data at the same time. At first, the radio agent calculates the number of required time slots, u'_i, for ith user by the following equation.

$$u'_i = \left\lceil U \times \frac{\beta_i}{k_i \Delta f} \right\rceil \tag{1}$$

k_i [bps/Hz] is the normalized data rate of 2^{k_i}-QAM. If QPSK modulation is used, k_i equals 2 ($k_i = 2$). β_i [bps] is the required bit rate of video stream for ith user, and Δf [Hz] is the all the usable bandwidth. U is the number of time slots of one TDM frame. The ceiling function $\lceil\ \rceil$ which gives the smallest integer greater than or equal to the given numeric expression. Equation (1) is calculated from k_i, Δf, U and β_i. For example, if k_i is 2 [bps/Hz], Δf is 12 [MHz], U is 32, and β_i is 2 [Mbps], u'_i becomes 3. Therefore, 3 time slots are calculated as required time slots, u'_i.

Then, the proposed algorithm allocates time slots for Class 0 and Class 1 user. The allocated time slot, u_i, of the ith user is calculated as follows.

$$u_i(S_c) = u'_i \quad (S_c = 0 or 1) \tag{2}$$

If service class of ith user is Class 1 ($S_c = 1$), u'_i is assigned to u_i. This allocation is able to guarantee the required time slots, u', for real-time stream user.

After allocating time slots to Class 0 and Class 1 users, the proposed algorithm calculates the resource coefficient, α, which is described in Sect. 2.2.1, in Eq. (3).

$$\alpha = \frac{U - \sum_{i=1}^{n} u'_i}{U'_3} \tag{3}$$

U'_3 is the sum of the Class 3 users' required time slots, u'. This coefficient shows an available time slots after allocating required time slots, u', for all users. If $\alpha > 0$, there is an available bandwidth allocating for Class 3 user.

To allocate the time slots to Class 2 and Class 3 user, the proposed algorithm judges whether the resource coefficient α satisfies the following inequality or not.

$$\alpha \geq 0 \tag{4}$$

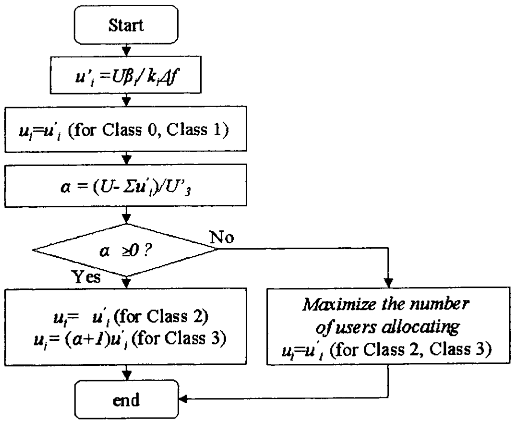


Fig. 2 The flow chart of the proposed algorithm.

If the inequality (4) is satisfied, there is an available bandwidth allocating for Class 3 user. Therefore, the allocated time slot ui for Class 2 or Class 3 user is calculated as follows.

$$u_i(S_c) = \begin{cases} u'_i & (S_c = 2) \\ (\alpha + 1)u'_i & (S_c = 3) \end{cases} \tag{5}$$

The main purpose of the proposed algorithm is to allocate more time slots to the Class 3 user. In Eq. (5), $(\alpha + 1)$ satisfies $(\alpha + 1) \geq 1$ because the inequality (4) is satisfied. Therefore, the Class 3 user is more prioritized than the other service class user when there are available time slots. On the other hand, if the inequality (4) is not satisfied, it means that satisfying the required time slots, u', for Class 2 and Class 3 user is difficult. Therefore, time slots are allocated to maximize the number of Class 2 and Class 3 user who satisfies the required time slot.

$$u_i(S_c) = \begin{cases} u'_i & (S_c = 2) \\ u'_i & (S_c = 3) \end{cases} \tag{6}$$

Users who do not allocate the time slots are rejected its request.

The proposed algorithm starts calculating when a new user requests the data, the user completes to retrieve its request or a moving user who retrieves the data leaves out the spot. Figure 2 show the flow chart of the proposed algorithm.

3. Performance Analysis

3.1 Simulation Parameters

The computer simulation model is illustrated in Fig. 3. We assume that user requests real-time stream or non-real time stream with probability P_r and $1 - P_r$ respectively. P_r is real-time stream probability which user requests the real-time video stream. The required bit rate of real-time and non-real time stream is R_1 and R_2 respectively. The service time of the video stream is assumed 60 [sec] for both real-time and non real-time video stream. The buffer size of the terminal is assumed large enough to accommodate the video stream of 60 [sec]. We assume that two types of user are assumed to request the data. The first one is a moving user whose dwell time in an access spot is smaller than the service time of the video stream of 60 [sec]. We assume that the speed of moving user follows the normal distribution on averaged of 9 [km/h]. The average dwell time of a moving user is about 20 [sec] which is smaller than the service time of video stream. The second one is static user whose dwell time is long enough to retrieve all the video stream at the wireless LAN spot. For simplicity of simulation model, we assume that static user goes through the constant speed of 3 [km/h] in the wireless LAN spot. Therefore, the dwell time of the static user is 60 [sec] in this simulation. We also assume that a new user who arrives at the spot becomes a moving user with probability P_m or static with probability $1 - P_m$. The user interval is assumed exponential distribution. It is also assumed that the mobility estimator is able to distinguish the moving and static users correctly. Table 4 shows the parameters used in this simulation. The shape of the access spot is rectangle and the long side of the rectangle is set to 50 [m]. Users walk the access spot along the long side of the rectangle. The frequency and its bandwidth are based on the IEEE 802.11a standard. Modulation format is selected QPSK modulation. The TDM frame length is 10 [msec] and one TDM frame has 32 time slots ($U = 32$). The Rice fading channel is assumed in a wireless environment and the average channel CNR is assumed to be the same in every access spot. The average interval of the re-

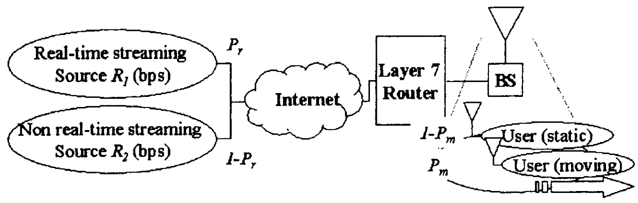


Fig. 3 Simulation model of proposed spot wireless LAN system.

Table 4 Simulation parameters.

Channel model	Rice fading channel (k = 5 [dB])
Frequency band	5.2 GHz
Bandwidth Δf	12MHz
Spot length	50m
Maximum user number	8
Moving user speed	Normal distribution (Ave 9 km/h, σ = 2 km/h)
Static user speed	3 [km/h]
Average moving user dwell time	20 [sec]
Static user dwell Time	60 [sec]
Video service time	60 [sec]
User interval	Exponential distribution (Ave 20 [sec])
Multiple format (downlink)	Dynamic TDM (U = 32 [slots])
Frame Length	10 [msec]
Modulation format	QPSK

start of the proposed algorithm is between several seconds and several tens of seconds in this simulation. It is long enough compared with the frame length for transmitting the speed information. Therefore, the overhead to transmit the speed information via uplink is ignored in this simulation.

In this paper, we evaluate the average service time performance of the proposed scheme. We define the average service time T_{ave} as the average value of the received service time T_s among the users. We define "the received service time performance T_s" as the received data size, that is, the playing period users are able to play the video stream continuously with satisfying both the required bit-rate and the no transmission delay in the wireless link. For example, if a user is able to play 20 [sec] video stream continuously, the received service time is 20 [sec].

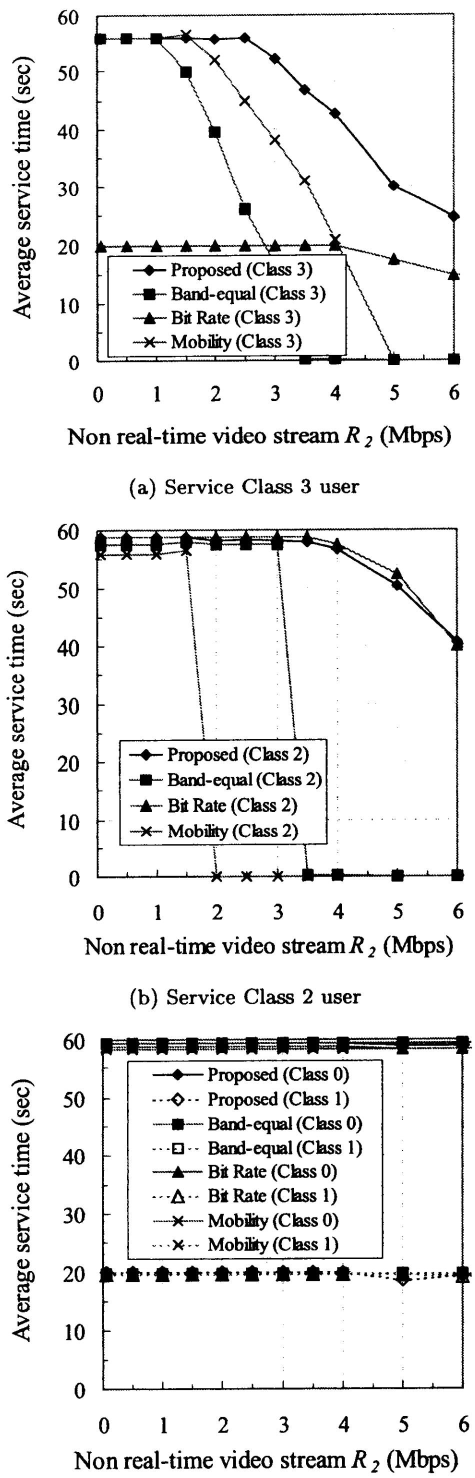
3.2 Average Service Time Performance for Each Service Class

Figures 4(a), (b) and (c) show the average service time performance for each service class versus the non real-time stream bit rate R_2. In this figure, parameters R_1, P_r, P_m are assumed 64 [kbps], 0.5 and 0.5 respectively. For comparison, the performance of the "Band-equal," "Bit Rate" and "Mobility" schemes are also shown. Band-equal scheme allocates the bandwidth equally for all users. Therefore, time slots are allocated $u_i = U/n$ with n users. Bit Rate scheme allocates bandwidth to satisfy the required bit rate β of user and without considering the service class S_c. Time slots are allocated $\alpha = 0$ in Eq. (5). Mobility scheme allocates the bandwidth with considering user mobility m without considering the required bit rate β and traffic category S_c. It shows the equivalent performance with the adaptive wireless transmission scheme proposed in reference [9]. The allocated time slot u is calculated to satisfy Eq. (7).

$$u_1 : u_2 : u_3 : \ldots : u_n = v_1 : v_2 : v_3 : \ldots : v_n \tag{7}$$

v is the movement speed of a user. Moving user is allocated about 3 times time slots as large as that of static user in the simulation parameters.

It is seen from Fig. 4(a) that the proposed scheme shows the best performance for Class 3 users compared with the conventional schemes. When R_2 is 64 [kbps], the performance of the proposed scheme, Band-equal scheme and Mobility scheme are 56.4 [sec], 55.8 [sec] and 56.0 [sec] while the performance of the Bit Rate scheme are 19.8 [sec]. The performance of the Bit Rate scheme is restricted by the user's dwell time of 20 [sec] on an average because the Bit Rate scheme does not consider the user mobility. Band-equal scheme and Mobility scheme also achieve about the same performance compared with the proposed scheme because these conventional schemes are able to allocate large enough time slots to transfer the non real-time stream for Class 3 user when R_2 is small. However, these conventional schemes degrade when R_2 is larger than 2 [Mbps]. For example, the performance of the proposed scheme for Class 3 user at R_2 = 2.5 [Mbps] is 56.4 [sec] while the performance of the Band-equal, Bit Rate, Mobility, are 25.2 [sec], 19.8 [sec] and 45.0 [sec] respectively. This is because the proposed allocation scheme gives high priority and allo-



(a) Service Class 3 user

(b) Service Class 2 user

(c) Service Class 0 and Class 1 user

Fig. 4 Average service time performance for each service class user versus non real-time video stream R_2 (R_1 = 64 kbps).

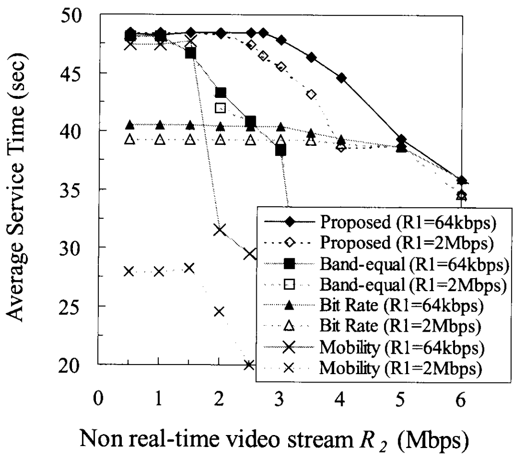


Fig. 5 Average service time performance for all users versus non real-time video stream R_2.

cates more time slots for the Class 3 user in Eq. (5). The performance of the Mobility scheme is better than Band-equal scheme because Mobility scheme gives high priority for Class 3 user. However, the performance of the proposed scheme is better than the Mobility scheme. This is because Mobility scheme allocates more time slots for Class 0 and Class 1 user than the proposed scheme. It decreases the number of the allocated time slots for Class 3 user of the Mobility scheme. It is seen from Fig. 4(b) that the proposed scheme and Bit Rate scheme shows the best performance for Class 2 user. The performance of the Band-equal scheme and Mobility scheme starts degrading at R_2 = 3 [Mbps] and R_2 = 1.5 [Mbps] respectively. This is because these conventional schemes allocate the time slots without considering the required bit rate β. Especially in this simulation, when maximum 8 users share the 12MHz bandwidth with QPSK modulation, Band-equal scheme and Mobility scheme allocate 3 [Mbps] and 1.5 [Mbps] for Class 2 user respectively. It is seen from Fig. 4(c) that the proposed scheme shows the same performance for Class 0 and Class 1 user with the Band-equal scheme, Bit Rate scheme and Mobility scheme. It is also seen Fig. 4(c) that the performance of the all resource allocation scheme for the Class 1 user is about 20 [sec] although the service time of the video stream is 60 [sec]. This is because the performance is restricted by the user's dwell time although users are allocated enough time slots to transmit the real-time stream of 64 [kbps]. However, Class 1 user achieves to receive the real-time stream service through to the end of its dwell time of 20 [sec] on an average.

It is seen from Figs. 4(a), (b) and (c) that, when the required bit rate of R_1 is 64 [kbps], the performance of the proposed scheme exhibits the best performance for all service class regardless of R_2. This is because proposed scheme considers the required bit rate of the video source and give high priority to the Class 3 user, who requests the non real-time video stream with moving.

Figure 5 shows the average service time performance for all users versus the non real-time stream bit rate R_2. In this figure, parameters P_r, P_m are assumed 0.5 and 0.5 respectively. The performance of the proposed scheme at R_1 = 64 [kbps] or 2 [Mbps] is analyzed. For comparison, the performance of the "Band-equal," "Bit Rate" and "Mobility" schemes are also shown. It is seen from Fig. 5 that, proposed scheme exhibits the best performance at R_1 = 64 [kbps] compared with the Band-equal scheme and Bit Rate scheme and Mobility scheme. It is also able to analyze from Figures 4(a), (b) and (c). It is also seen from Fig. 5 that, proposed scheme exhibits the best performance at R_1 = 2 [Mbps] compared with the conventional schemes. It is seen from Fig. 5 that the performance of the proposed scheme improves when R_1 is small. For example, when R_2 is 4 [Mbps], the performance of the proposed scheme at R_1 = 64 [kbps] and R_1 =2 [Mbps] are 44.6 [sec] and 40.4 [sec] respectively. This is because, when the R_1 is small, the proposed scheme allocates more time slots to the Class 3 user by distinguishing the kinds of real-time and non real-time video stream. It is seen from Fig. 5 that the performance of the proposed scheme is about the same performance of the Bit Rate scheme when R_2 is larger 4 [Mbps]. This is because the priority for Class 3 user in Eq. (3) closes to 0 (α = 0) when R_2 is larger than 4 [Mbps].

3.3 Average Service Time Performance versus User Mobility and Video Stream Kinds Scenario

Figures 6(a), (b), (c) and (d) shows the average service time performance for each service class versus user moving probability P_m. In this figure, R_1 and R_2 is 2 [Mbps] and 2 [Mbps] respectively. The performance of the proposed scheme at P_r = 0.75, 0.5 or 0.25 are shown. For comparison purpose, the performance of the "Band-equal," "Bit Rate" and "Mobility" scheme are also shown. It is seen from Fig. 6(a) that when P_r is large, the proposed scheme exhibits the best performance for Class 3 user compared with the Band-equal, Bit Rate and Mobility scheme for all P_m. For example, when P_r is 0.75 and P_m is 0.875, the performance of the proposed scheme is 56.8 [sec] while the performance of the Band-equal scheme, Bit Rate scheme, and Mobility scheme are 31.8 [sec], 19.8 [sec] and 34.0 [sec] respectively. This is because, when P_r is large, the number of the Class 3 user decrease and allocated time slots for each Class 3 user increases in Eq. (3). It is also Fig. 6(a) that when P_r is small, the performance of the proposed scheme decreases. However, the proposed scheme exhibits slightly better performance than the conventional schemes. It is seen from Figs. 6(b), (c) and (d) that the proposed scheme exhibits the same performance for Class 0, Class 1, and Class 2 user for all P_r and P_m. This is because the proposed scheme allocates the time slots to satisfy the required bit rate for Class 0, Class1 and Class 2 user firstly.

The result in this section shows that the proposed allocation scheme can achieve the best performance for all service class users compared with the conventional schemes regardless of user moving probability P_m and real-time stream

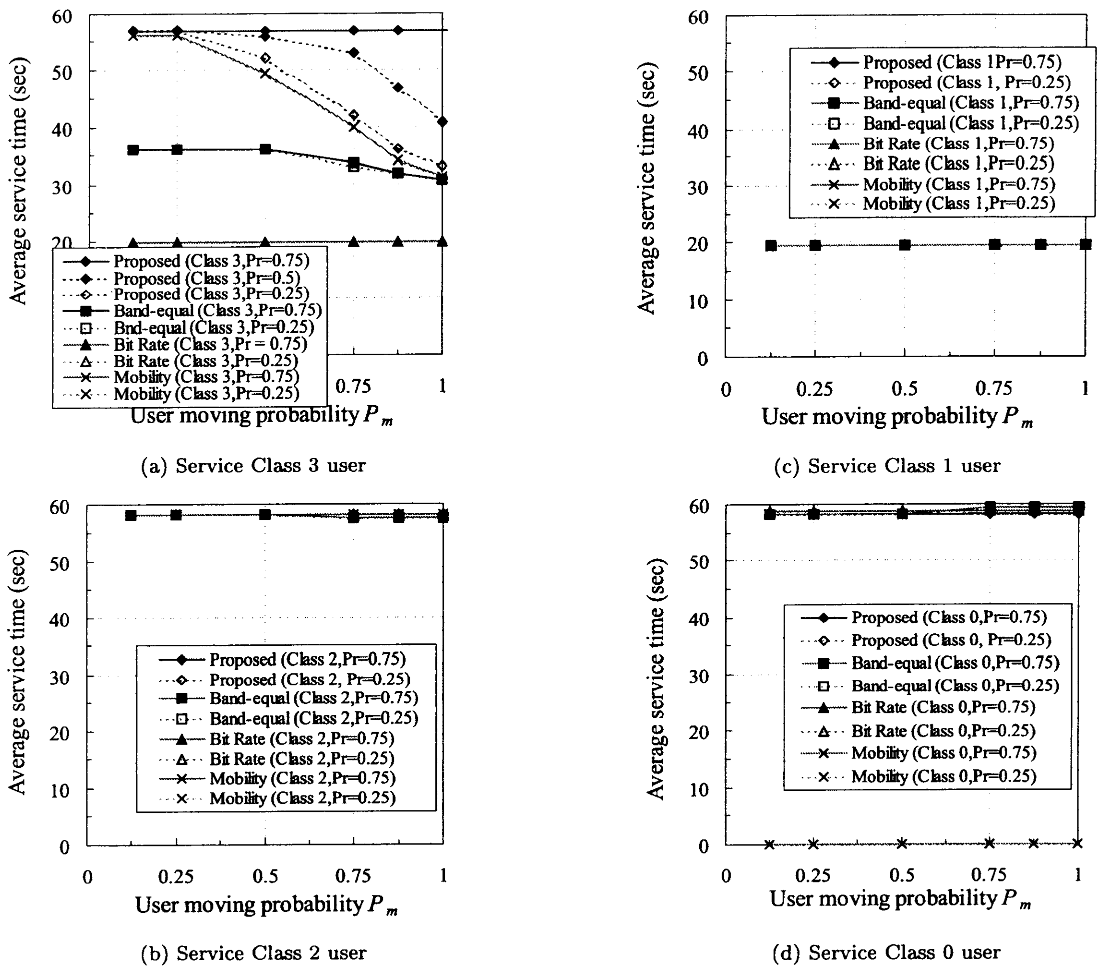


Fig. 6 Average service time performance for each service class user versus P_m and P_r.

probability P_r.

4. Coclusion

We have proposed the adaptive resource allocation scheme for video stream based on video stream character and user's mobility in wireless LAN. The proposed scheme allocates the time slots adaptively for each user according to the user mobility, the required bit rate, and the kinds of the video stream. It can solve the frequency utilization efficiency in the environment with various user behaviors. Assuming the situation that moving or static users request the video stream in a wireless LAN spot, the results of computer simulation verified that the proposed scheme gives much the better performance than conventional scheme.

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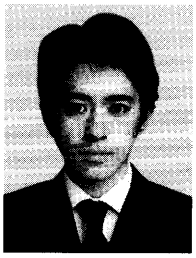

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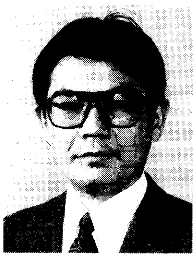

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