Dynamic Channel Allocation for Class-Based QoS Provisioning and Call Admission in Visible Light Communication

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Abstract Provisioning of quality of service (QoS) is a key issue in wireless communication systems. Owing to the fact that QoS requirements are not very strict for all traffic types, more calls of higher priority traffic classes can be accommodated by blocking a slightly greater number of calls of lower priority traffic classes. Diverse types of high data rate traffic are supported by existing wireless communication systems, although resources are limited. Hence, priority-based resource allocation can ensure sufficient service quality for calls of important traffic classes. However, the use of fixed guard channels to prioritize any class of calls always reduces channel utilization. Hence, we propose a priority-based dynamic channel reservation scheme for higher priority calls that does not reduce channel utilization significantly. The number of reserved channels for each individual traffic class is calculated using real-time observation of call arrival rates for all traffic. The scheme reduces the call blocking probability for higher priority calls while simultaneously increasing channel utilization. The proposed channel reservation scheme can be efficiently applied for visible light communication (VLC) systems as well as for other wireless communication systems. The proposed Markov Chain model is expected to be very effective for queuing analysis and particularly for implementing a priority-based scheme for any number of traffic classes. We consider VLC as the system model for performance analysis. The numerical results show that the proposed scheme is able to attain a reasonable call blocking probability for higher priority calls, without sacrificing channel utilization.

Keywords QoS · Visible light communication · Priority users · Call blocking probability · Channel allocation

1 Introduction

The trend in wireless communication systems is an increase in traffic related to a variety of multimedia applications,
which increases the traffic load on wireless networks. Among the various classes of traffic, a few are more important than others, e.g., traffic related to security, healthcare, banking, and handover calls. During the resource allocation, these important classes of traffic are given higher priority through different mechanisms. Blocking a lower priority call is preferred over blocking one of higher priority when available system resources are running low. Several schemes (e.g., in [1–5]) have been proposed that allow higher priority for a particular class of traffic (e.g., a handover call). Most of these schemes are based on the notion of a fixed guard band and quality of service (QoS) adaptability. In a fixed guard band scheme, a number of channels are reserved for exclusive use by a particular class of traffic. Schemes based on QoS adaptability reduce resource allocation for ongoing calls to accept more calls of higher priority. Although the schemes based on fixed guard bands [1] employ a simple mechanism to reduce the call blocking probability for higher priority traffic calls, these schemes also result in reduced bandwidth utilization. QoS adaptability [2–5] for traffic allows assignment of a higher priority for higher priority traffic classes. However, these schemes can only be implemented on a system that can permit variable bandwidth allocation for calls (e.g., a circuit switching system does not allow fractional channel allocation). In addition, the service applications must be compatible with QoS adaptability (e.g., real-time voice calls need guaranteed bandwidth). Therefore, a dynamic channel allocation scheme is required for priority-based resource allocation on systems that cannot achieve QoS adaptability.

Recently, environmentally friendly and energy-efficient wireless communication systems have experienced rapid development and have garnered considerable interest. One such system is visible light communication (VLC), which uses visible light as a high data rate transmission medium. It is being touted as one of the most promising wireless communication technologies for the next generation of networks. VLC is a short-range optical wireless communication technology utilizing light-emitting diodes (LEDs), which can provide both illumination and communication simultaneously. Nowadays, there are a growing number of applications for visible-light LEDs, such as for traffic lights and for illumination in homes, hospitals, and hotels. These LEDs have very low power consumption and an extremely long operational life, small size, and rapid response time. The LEDs also maintain an almost constant chromaticity over time. In addition, LEDs can be used as transmitters for communications, without affecting their main functionality, i.e., illumination. An indoor wireless network that relies on existing LEDs that are also used for illumination would probably be easier and more cost-effective than other alternatives. VLC systems not only have the usual capabilities of wireless optical transceivers but are also robust to electromagnetic (EM) interference and are more secure against undesired network access. From a security perspective, VLC is slightly different from other wireless networks owing to the directionality and visibility of the medium. As a result of these features, an unauthorized receiver that is in the path of the communication signal can be easily recognized. In addition, the signal does not travel across opaque obstacles such as walls, unlike radio frequency based wireless networks. These features of VLC allow it to be used in concert with commercial radio frequency networks such as WiFi and Bluetooth, particularly indoors.

Visible light communication is a new and promising communication technology that can meet the future demands of wireless users. However, an appropriate resource allocation strategy for the VLC networks has not yet been developed. Therefore, we propose a dynamic channel allocation scheme for multi-class services on a VLC network. Moreover, the same scheme can be efficiently used on other types of wireless networks, as well. According to the specification [6], VLC systems use seven individual wavelength bands for communication. Each band should be carefully used to minimize interference. In addition, each VLC transmitter can support only a limited number of users. With a combination of these seven bands, a limited number channels can be implemented. If multiple-classes of traffic such as voice, video, and data are being aggregated simultaneously on the network, each class can be allocated to a different band. Resources are allocated to each type of user on the basis of the priority and instantaneous condition of the color channel to maintain the QoS on a VLC network. To meet QoS requirements, all traffic classes are not assigned the same priority. Given the limited number of available channels on VLC networks, when high data rate services are being used during heavy traffic conditions, only an efficient priority-based call admission control (CAC) mechanism can ensure very low call blocking probability for the higher priority users, e.g., handover calls, link recovery [7] calls, and conversational voice calls, without sacrificing resource utilization. A scheme that does not assign priorities, that is, treats all traffic equally, will suffer from very high call blocking probability for the higher priority traffic during periods of high traffic. The proposed priority-based scheme employs dynamically reserved channels to increase channel utilization while simultaneously reducing the call blocking probability for higher priority calls. Call connection requests are classified into multiple classes such as class 1, class 2, . . . . class M. The number of available channels for a call of a particular class varies with the call arriving rates of all traffic classes. The use of dynamically reserved guard channels ensures higher channel utilization along with a lower call blocking probability for higher priority traffic calls. The proposed scheme employs real-time estimation of the call arrival rate to determine the number of channels that must be reserved for each traffic class.
The rest of this paper is organized as follows: Section 2 introduces the service scenario and optical channel model for VLC. The proposed dynamic channel allocation scheme, including the system model and queuing analysis, is presented in Sect. 3. In the same section, we also derive the formula for the call blocking probability for any class of traffic calls. Section 4 presents the numerical performance evaluation results for our proposed scheme. Finally, we present our conclusions in Sect. 5.

2 VLC Service Scenario and Optical Channel Model

2.1 Service Scenario

A basic indoor VLC service scenario is shown in Fig. 1. Lighting and communication are provided by a number of VLC transmitters, i.e., LED arrays. These VLC transmitters are fixed to the ceiling. A terminal with an optical receiver is placed on a receiving plane, such as a desk, and data is received from the LEDs. In Fig. 1, the VLC network is connected to a power line communication (PLC) network, cellular network, or IP network. The VLC network can be used for high-definition television (HDTV) broadcast, audio services, high-speed Internet, video streaming, and supporting various services on smart phones. The diverse types of traffic require different QoS levels. Channels are allocated dynamically on the basis of the priority, requirements, and desired QoS level for each traffic class.

Figure 2 shows an example of a VLC implementation in an outdoor environment. Free-space optical (FSO) communication, a type of VLC, is an optical communication technology that uses light propagation in free space to transmit data. FSO communication networks can be installed on highways or train/subway lines. FSO access points (APs) are installed every 2 or 3 km. The FSO APs are connected to optical fiber backbone networks. Optical transceivers are installed on the outside of a vehicle. Inside the vehicle, WiFi, femtocell [8], or other indoor wireless networks are installed, which users can connect to. However, the FSO AP is used for backhaul. This application of VLC can support a large number of users in vehicles.

On a VLC network, line-of-sight (LOS) between two transceivers should be ensured owing to the nature of visible light. In addition, visibility support is needed to facilitate initial access for link re-connection and to identify the nature of any obstacle that interrupts communication. This visibility support requires the use of certain optical channels.

2.2 Optical Channel Model and Color Band

The bandwidth of an optical channel in the LOS configuration is reported to be greater than 88 MHz [9]. Here, we describe the behavior of the optical channel when a visible optical signal passes from the transmitter to the receiver. The received power depends on the optical channel gain and the transmitted power. The optical channel gain can be expressed in terms of the transmitted and received powers as follows:

\[ P_r = H(0)P_t \]  

where \( P_r \) is the transmitted optical power, \( P_t \) is the received optical power, and \( H(0) \) is the channel DC gain.

Considering an LOS link, the channel DC gain is defined as follows [10]:

\[ H_{\text{LOS}} = \begin{cases} \frac{(\tau+1)A}{2\pi D^2} \cos^4(\phi) T_s(\psi) g(\psi) \cos(\psi), & 0 \leq \psi \leq \psi_c \\ 0, & \text{elsewhere} \end{cases} \]  

where \( \tau \) is the order of Lambertian emission, \( A \) is the photodetector area, \( D \) is the distance between the transmitter and the receiver, \( \phi \) is the angle of irradiance, \( \psi \) is the angle of incidence, \( T_s(\psi) \) is the signal transmission coefficient of the optical filter, \( g(\psi) \) is the gain of the optical concentrator, and \( \psi_c \) is the receiver’s field of view (FOV).

The order of Lambertian emission \( \tau \) can be found from equation \( \tau = -\frac{\ln 2}{\ln(\cos \phi_1/2)} \), where \( \phi_{1/2} \) is the transmitter’s half-power angle. The gain can be determined from the following expression [10]:

\[ g(\psi) = \begin{cases} \frac{\psi^2}{\sin^2(\psi_c)}, & 0 \leq \psi \leq \psi_c \\ 0, & \text{elsewhere} \end{cases} \]
Fig. 2 VLC outdoor application scenario where free-space optical (FSO) communication is used for the users on a train.

Table 1 VLC band plan

| Color band | Wavelength range (nm) | Spectral width (nm) |
|------------|-----------------------|---------------------|
| Band 1     | 380–450               | 70                  |
| Band 2     | 450–510               | 60                  |
| Band 3     | 510–560               | 50                  |
| Band 4     | 560–600               | 40                  |
| Band 5     | 600–650               | 50                  |
| Band 6     | 650–710               | 60                  |
| Band 7     | 710–780               | 70                  |

where \( v \) denotes the internal refractive index of the optical concentrator.

A VLC device operates in one or several color bands with peak radiated energy within the visible light wavelength spectrum (380–780 nm), as summarized in Table 1.

Human eye sensitivity is not equal for all the color bands. Therefore, visible LEDs are designed to match the human eye sensitivity and to support up to seven independent and parallel bands according to the VLC specification [6]. Using a combination of these seven bands, we can create a maximum of \( 2^7 - 1 \) channels (the channel bit pattern 0000000 is not used). Therefore, the maximum number of channels is limited on a VLC network. The bit patterns for selecting single or multiple color bands are summarized in Table 2 [6]. The bit patterns 0000001 and 1000000 represent the selected color bands 7 and 1, respectively. The bit pattern 0100110 indicates that the selected bands for communication are 2, 5, and 6. When a VLC device supports multiple color bands, one can optimize the link by choosing the band that can deliver the best performance and network capacity. In VLC, separate bands can be used for receiving and transmitting data simultaneously.

Table 2 Color band selection for multiple channels (\( X = \text{not used} \) and \( O = \text{used} \))

| Bit pattern | Band 1 | Band 2 | Band 3 | Band 4 | Band 5 | Band 6 | Band 7 |
|-------------|--------|--------|--------|--------|--------|--------|--------|
| 0000001     | X      | X      | X      | X      | X      | X      | O      |
| 000010     | X      | X      | X      | X      | O      | X      |
| ...         | X      | O      | X      | X      | O      | O      | X      |
| ...         | 1000000 | O      | X      | X      | X      | X      | X      |
| ...         | 1111111 | O      | O      | O      | O      | O      | O      |

3 Proposed Channel Allocation Scheme

The radio resource management module is responsible for the efficient utilization of air interface resources to ensure a certain QoS level for different users according to their traffic profiles [11]. Many prioritization schemes for mobile networks have already been proposed by different researchers to reduce the handover call dropping probability or to reduce the call blocking probability for higher priority calls [1–5, 12, 13]. If fixed guard channels [1] are used to prioritize any class of calls, then system resource utilization is always reduced. Moreover, if the scheme is based on QoS adaptability [2–5], then the system and the application must be compatible with QoS adaptability, which may not be possible for all wireless networks and service environments. The channel borrowing scheme [5] results in increased signaling overhead owing to the communication among neighboring cells. Therefore, we need a prioritization scheme for environments that do not support the QoS adaptability (such calls cannot run on reduced bandwidth) to assign a higher priority to the important class of traffic calls. A priority-based dynamic channel allocation scheme for VLC networks ensures a lower call
blocking probability for the higher priority traffic classes and maintains higher channel utilization. In this section, we propose a dynamic guard channel scheme that increases channel utilization as well as reduces the call blocking probability for higher priority calls. The number of available channels for a particular class of traffic varies with the call arrival rates of different traffic classes. We propose a queuing analysis model to calculate the call blocking probability and a technique to estimate the call arrival rate. Even though we use VLC as a model for the proposed scheme, the proposed scheme is also applicable to other wireless networks, particularly those that do not support QoS adaptability.

3.1 Dynamic Channel Allocation

Let traffic classes 1, 2, 3, ..., \( m \), ..., \( M \), respectively, represent the highest to lowest priority. \( \lambda_T \) and \( \lambda_m \) are the total call arrival rate and the call arrival rate for traffic class \( m \), respectively. Hence,

\[
\lambda_T = \lambda_1 + \lambda_2 + \cdots + \lambda_m + \cdots + \lambda_M \quad (4)
\]

Suppose \( N \) is the total number of channels in the system and \( \Gamma \) is the maximum allowable number of channels that can be reserved (equivalently, guard channels). The reservation of channels for various traffic classes is based on the priority of the traffic classes. The remaining \((N - \Gamma)\) channels are equally shared by traffic of all classes. The value of \( \Gamma \) should not be very high in order to maintain better channel utilization.

The number of channels reserved for the traffic classes 1, 2, ..., and \( m \) is as follows:

\[
X_m(t) = \frac{\lambda_m}{\lambda_T} \Gamma \quad (5)
\]

Alternatively, term \( \Gamma \) can be expressed as follows:

\[
\Gamma = \sum_{i=1}^{M} X_i(t) \quad (6)
\]

Along with \((N - \Gamma)\) channels, \(|X_M(t)|\) number of channels are also equally shared by all traffic classes.

The number of accessible channels among \( \Gamma \) for the \( m \)th class of traffic calls is as follows:

\[
y_m(t) = \sum_{i=m}^{M} X_i(t) \quad (7)
\]

The total number of accessible channels for the traffic class \( m \) is as follows:

\[
N_m = N - \Gamma + y_m(t) \quad (8)
\]

Equations (5)–(8) show that the channels allocated to the different traffic classes are not fixed. The numbers of accessible channels for various traffic classes vary with \( \lambda_m \), \( \lambda_T \), \( N \), and \( \Gamma \). At a particular time, the maximum number of channels \( N_m \) available for traffic class \( m \) can be calculated by measuring the call arrival rates.

The optimum value of \( \Gamma \) can be decided on the basis of several techniques. The simplest way is to choose a value through several observations of channel utilization and call blocking rates. However, \( \Gamma \) can also be dynamically adjusted on the basis of the expected minimum channel utilization, the traffic congestion condition, and the initially input value of \( \Gamma \). Suppose \( \eta_{\min} \) and \( \eta_p \) are the minimum expected channel utilization and the current channel utilization, respectively. The optimum value of \( \Gamma \) can be calculated as follows:

\[
\Gamma = \begin{cases} 
\Gamma_0, & \eta_p \geq \eta_{\min} \\
\Gamma_0 \left(1 - \frac{\eta_{\min}}{\eta_p}\right), & \eta_p < \eta_{\min}
\end{cases} \quad (9)
\]

where \( \Gamma_0 \) is the initially input value of \( \Gamma \).

Equation (9) shows a simple way to find the optimum value of \( \Gamma \) under dynamic network traffic conditions. Whenever the channel utilization is lower than the expected minimum, the system reduces the value of \( \Gamma \) to compensate. The initial input value can be decided on the basis of several observations of channel utilization and call blocking rates.

Figure 3 shows the system model for the proposed dynamic channel reservation scheme. The proposed scheme reserves a non-fixed number of channels for traffic of class \( m \). The number of accessible channels depends on the priority of the traffic class and the call arrival rates for different traffic classes. The minimum number of channels available for all traffic classes is \((N - \Gamma)\), when \( \Gamma \) channels are allocated on the basis of the priority of the traffic class. Higher priority traffic classes have a higher number of channels available to them. A call request of traffic class \( m \) can be accepted only if the number of already occupied channels is less than \( N_m \).

3.2 Queuing Analysis

Call admission control for the proposed scheme is implemented as shown in Fig. 4. Whenever a call of traffic class \( m \) arrives, the system estimates the call arrival rates for all the traffic classes to determine the maximum number of accessible channels \( N_m \) for traffic class \( m \). A call of traffic class \( m \) can be accepted only if the number of already occupied channels is less than \( N_m \).

The proposed scheme can be modeled as an \( M/M/N/N \) queuing system [14]. The Markov Chain for queuing analysis of the proposed scheme is shown in Fig. 5. We define \( 1/\mu \) as the average channel holding time (exponentially distributed). The probability that the system is in state \( i \) is given by \( P_i \).
Fig. 3 System model for the proposed scheme to admit a call

From Fig. 5, the state balance equations are as follows:

\[
\begin{align*}
    i \mu P_i &= \lambda T P_{i-1}, \quad 0 \leq i \leq N_M \\
    i \mu P_i &= (\lambda T - \lambda M) P_{i-1}, \quad N_M < i \leq N_{M-1} \\
    i \mu P_i &= \left(\lambda T - \sum_{j=m}^{M} \lambda_j \right) P_{i-1}, \quad N_m < i \leq N_{m-1} \\
    i \mu P_i &= (\lambda_1 + \lambda_2) P_{i-1}, \quad N_3 < i \leq N_2 \\
    i \mu P_i &= \lambda_I P_{i-1}, \quad N_2 < i \leq N_1 \\
\end{align*}
\]

A call of the \( m \)th class is blocked in the proposed scheme if the number of ongoing calls is \( N_m \) or larger. \( N_M \) is the maximum number of accessible channels for the lowest priority (\( M \)th class) traffic class, whereas \( N_1 \) is the maximum number of accessible channels for the highest priority (traffic class 1) traffic class. The highest priority calls are blocked only when all of the total \( N \) channels (also denoted by \( N_1 \)) are occupied by ongoing calls. The generalized equations to calculate the blocking probability for any call of traffic class \( m \) among the total \( M \) number of traffic classes are derived using queuing analysis. The call blocking probability for a call of the highest priority traffic class is calculated using (11). On the other hand, the call blocking probabilities for the traffic classes 2 and higher are calculated using (12). This Markov Chain model can be effectively applied for queuing analysis, particularly for a priority-based scheme for any number of traffic classes.

\[
B_1 = P_N = \frac{\lambda M}{\mu N} P_0 \frac{N^M}{N!} \prod_{k=1}^{M-1} (\lambda_1 + \lambda_2 + \ldots + \lambda_{M-k})^{N_{M-k} - N_{M-k+1}}, \quad m = 1
\]
The average call arrival rate ($\lambda_m$) for the $m$th class traffic considering the last $(n + 1)$ call arrivals is calculated as follows:

$$\frac{1}{\lambda_m} = \frac{\Delta T^m}{n} = \frac{1}{n} \sum_{i=1}^{n} \Delta t_i^m$$

(16)

Because $\Delta T^m$ is an unbiased estimate, $\lambda_m$ is also an unbiased estimate. Hence, $\lambda_m$ in (16) is used as an estimate of the call arrival rate for traffic class $m$. Using (5)–(7) and (14)–(16), (8) can be expressed as follows:

$$N_m = \left[ N - \sum_{j=1}^{m-1} \frac{1}{\sum_{i=1}^{j-1} \Delta t_i} \right] \Gamma$$

(17)

Here, we consider only the last $(n + 1)$ call arrivals to obtain the real-time traffic conditions. As we consider only $(n + 1)$ call arrivals for the calculation of $N_m$, whenever a new call arrives, the sample for the $n$th call is replaced by the sample for the $(n + 1)$th call. Equation (17) indicates that the number of reserved channels for traffic class $m$ is high if $m$ represents a high priority traffic class. Hence, the number of accessible channels for a traffic class is dynamically varied depending on the call arrival rate, $N$, and $\Gamma$.

4 Performance Evaluation

As mentioned before, our scheme is applicable to VLC systems as well as other wireless communication systems. We perform numerical analysis of the proposed scheme based on VLC. We compared our proposed scheme with the performance of a non-priority scheme and the fixed guard channel scheme. According to the specification [6] of VLC, seven individual wavelength bands are for communication. To minimize interference, a room in a museum containing seven VLC transmitters i.e., LED lighting fixtures, is considered for the system model. Furthermore, according to the specification [6], the number of slots contained in any super-frame is 16. For beacon-enabled VLC personal area networks (VPANs), one slot can be reserved for the beacon [6]. As a result, one VLC transmitter can support 15 users simultaneously. Therefore, the system can support 105 users simultaneously within the room. When all the slots of a transmitter...
are full and a new user with higher priority arrives, the system allows diversion of one or more existing users to adjacent VLC transmitters based on a link switching procedure [6]. $f^*$ is considered to be 12. For convenience in the comparison with the fixed guard band scheme, we choose a fixed value of $f^*$. The fixed guard band scheme allows 105, 102, 98, and 93 channels for traffic of class 1, class 2, class 3, and class 4, respectively. The call arrival process is assumed to be a Poisson process and that the channel holding time is exponentially distributed with an average of 120 s. We consider a total of four classes of traffic in our analysis. Handover (or equivalently link switching) calls, link recovery calls, and voice calls are assigned to class 1 (priority 1); video calls are assigned to class 2 (priority 2); Internet browsing, buffered streaming video, and voice messaging are assigned to class 3 (priority 3); and background data traffic is assigned to class 4 (priority 4) for our analysis. In addition, 100 samples of each traffic class are used to estimate the call arrival rate. We compare the performance in terms of call blocking probability and channel utilization through two sets of results considering different traffic arrival conditions. The first set includes lower traffic arrival rates for the higher priority traffic classes (e.g., 1:2:6:3). The second set includes higher traffic arrival rates for higher priority classes (e.g., 5:3:2:2).

Figure 7 compares the call blocking probabilities when the ratio of traffic arrival rates for traffic classes 1, 2, 3, and 4 is set to 1:2:6:3. The non-priority scheme cannot ensure the QoS level in terms of call blocking probability for the higher priority users during higher traffic condition. Figure 7 shows that the proposed scheme provides significantly reduced call blocking probabilities for the higher priority users. Our scheme blocks more calls of lower priority (e.g., classes 3 and 4) to accommodate more higher priority calls (e.g., classes 1 and 2). The fixed guard band scheme also provides reduced call blocking probabilities for the higher priority users, but at the cost of significantly reduced channel utilization. Whenever the call arrival rates for higher priority classes of traffic are far lower than those of the lower priority classes, the proposed scheme reserves a smaller number of channels for the higher priority calls to maintain better channel utilization. Figure 8 shows that our proposed scheme does not significantly reduce the channel utilization compared with the non-priority scheme. However, to give the priority for the higher priority users, the fixed guard band scheme significantly reduces the channel utilization.

Figure 9 compares the call blocking probabilities when the ratio of traffic arrival rates for traffic classes 1, 2, 3, and 4 is set to 5:3:2:2. Because of the dynamic nature of channel reservation, our proposed scheme provides lower call blocking probabilities for higher priority users. Figure 9 shows that the proposed scheme is able to maintain the call blocking probability for traffic class 1 within a reasonable range even though the call arrival rate for this traffic class is much higher than that of the lower classes of traffic calls. When the traffic arrival rate of class 1 is very high, the system provides more channels for this class. Consequently, our scheme blocks more calls of traffic classes 2, 3, and 4 to accommodate more calls of traffic class 1 during heavy traffic. The fixed guard band scheme provides a slightly lower call blocking probability for users of traffic class 2 compared with
the proposed scheme. However, this reduced call blocking probability is accompanied by reduced channel utilization and increased call blocking probability for traffic of class 1. Whenever the call arrival rate for the higher priority traffic is much higher than that for the lower priority classes, our scheme reserves more channels for the former to accommodate the larger number. Figure 10 shows that although more channels are reserved to accommodate the large number of higher priority traffic calls, channel utilization is not significantly reduced.

As mentioned before, our proposed scheme reserves a non-fixed number of channels for different traffic classes. Figures 11 and 12 indicate the number of accessible channels for the \( m \)th class traffic calls under different traffic conditions. The number of accessible channels for each of the traffic classes is varied with the traffic arrival rate to maintain a low call blocking probability for higher priority users and to maintain better channel utilization. Whenever the call arrival rate for higher priority traffic calls increases, the number of reserved channels for calls of that priority is increased in our proposed scheme. Whenever the system resources are not sufficient to accommodate all call requests, our proposed scheme only blocks few more calls of the lower priority traffic classes to reduce the call blocking probability for the higher priority traffic classes, without reducing channel utilization significantly.

5 Conclusions

The appropriate resource allocation strategy for VLC networks is still an open question. Therefore, we proposed a dynamic channel allocation scheme for VLC networks. The proposed scheme can also be successfully applied to other wireless communication systems where multiple traffic classes are provided and resources are allocated on the basis of the priority of the traffic class. The concept of the proposed scheme is to dynamically reserve channels for different classes of users. Reserved channels are equivalent to
guard channels; however, the number of reserved channels is not fixed in our proposed scheme. This allows for higher channel utilization and lower call blocking probability for the higher priority users always. More channels are reserved for the higher priority traffic classes when the call arrival rate for the higher priority traffic classes is higher than that of the lower priority traffic classes; thus, a large number of higher-priority users can be accommodated. Therefore, the scheme gives higher priority for higher priority calls over lower priority calls, without sacrificing channel utilization significantly.

We have shown that the proposed scheme is quite effective in reducing the call blocking probability for higher priority users. The proposed scheme blocks slightly more calls of lower priority instead of blocking higher priority calls during heavy traffic. The proposed Markov Chain model will be very effective for queuing analysis and particularly for implementing a priority-based scheme for any number of traffic classes. The proposed scheme is expected to gain considerable acceptance in future multi-service VLC networks as well as other wireless networks, since the number of new traffic types with different QoS requirements is expected to further increase with the introduction of new applications.

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