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Spectrum handoff scheme for prioritized multimedia services in cognitive radio network with finite buffer

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***Abstract*—Multimedia applications have been becoming a majority type of traffic over cognitive radio network (CRN). Considering the different delay requirements of heterogeneous multimedia applications, we classified the secondary users (SUs) into four priority classes. Due to delay-sensitive nature of real-time (RT) multimedia services, we give it high priority to access channels. Non-real-time (NRT) traffic is characterized as delay-insensitive. In this paper, we proposed a dynamic spectrum handoff scheme with finite-size buffer queues to store preempted SUs which aims at avoiding the dropping events even though slightly increase the blocking probability. The finite-size buffer queue can avoid too many RT traffics piling up. Through limiting the buffer size the NRT traffics can get a fair chance to use channels. Additionally, spectrum sensing and channel allocation are controlled by a central base station (CBS). Such centralized admission control mechanism can efficiently prevent multiple SUs from simultaneously requesting to access the same spectrum band, consequently, to protect the channel form SUs' collision. A preemptive resume priority (PRP) M/M/c/c+k Markov model is established to analysis the performance, including the blocking probability, the throughput of SUs and the average completion time of RT traffic. The results show that the proposed scheme can meet the various performance requirements of heterogeneous multi-media applications. Moreover, the buffer mechanism can improve the channel utilization considerably.**

***Index Terms*—cognitive radio networks; multimedia transmission; buffer mechanism; admission control; spectrum handoff;**

I. INTRODUCTION

With the enormous spread of multimedia applications such as peer to peer (P2P) multimedia networks, Voice over IP (VoIP) and wireless devices have increased the requirements of spectrum resources. Cognitive radio technique is a more flexible and comprehensive spectrum management scheme which is also covering the shortage of fixed spectrum assignment scheme [1]. In a cognitive radio network (CRN), secondary users (SUs) operate in an opportunistic manner which means they can access spectrum resources if the primary users (PUs) temporarily leave. Once the PUs reoccupy the channel, the SUs oblige to return the channel and handoff to other vacant channels to resume the unfinished transmission. Therefore, the cumulative delay resulting from multiple handoffs is the key factor to guarantee the quality-of-service (QoS) [2].

In the previous literature of the spectrum handoff scheme over the CRN, some researches adopted dynamical spectrum access (DSA) with a channel reservation scheme to guarantee the transmission continuity. In [3] [4], both of them adopted a channel reservation scheme to reduce the forced termination probability at the expense of slightly increase blocking probability. However, channel reservation scheme wastes some valid channels because reserved channels only can be used by handoff users. New arrived users have no right to access reserved channels even if there is no handoff user occupies them. Buffering mechanism as a more optimal solution is introduced in some researches. In [5], the authors proposed a finite buffer queue to temporarily maintain the SUs' request on their arrival when all channels are occupied instead of directly blocking SUs. In [6] [7], the authors proposed multi-priority strategy to meet the performance requirements of heterogeneous SUs' traffics. But it is highly likely that two or more users may simultaneously request to access the same spectrum band. Most of research adopted admission control to coordinate transmission such as in [5] [8].

Almost none of these priori researches attempt to integrate the buffer mechanism, admission control scheduling policy and the prioritized strategy to improve the performance of multi-media transmission. In this paper, we proposed a novel dynamic spectrum handoff scheme for SUs with different priorities and buffer mechanism. It is noteworthy that we designed a special preemptive resume discipline to avoid force terminating in spite of increasing the blocking probability slightly. Except for PUs own the highest priority to access channel, we assume that there are four priority classes of SUs. In order to avoid dropping the preempted traffics that can not execute handoff to available channels immediately, a finite-size buffer queue was introduced to store them temporally. Through this way the suspended traffics in the buffer queue will resume transmission once the channels become idle. Additionally, spectrum sensing and channel allocation are controlled by a central base station (CBS) which means there is no necessary to detect the spectrum utilization behavior by every single SU. A preemptive resume priority M/M/c/c+k queuing network model is employed to analyze the proposed scheme. Furthermore, performance metrics are developed with respect to the blocking probability, the throughput of SUs and the average completion time of RT multimedia service.

The main contributions, which also indicate the major extension of the previous works, of this paper are as follows: 1. RT and NRT traffics which represent the delay-sensitive and delay-insensitive traffics respectively were given

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different priorities to access channels. In addition, we have distinguished the priority between preempted traffics and new arrival traffics. 2. A novel preemptive resumes discipline was designed to protect SUs' transmission from force terminating. 3. The average completion time of RT multimedia service and the throughput of NRT traffic were derived by Markov approach.

The rest of this paper is organized as follows. In section II, we will describe the proposed dynamical spectrum handoff scheme. Section III we present the mathematical derivation of performance metrics. In section IV, the numerical results were provided; Finally we draw conclusions in Section V.

II. PROPOSED DYNAMICAL SPECTRUM HANDOFF SCHEME

A. Prioritization of the Secondary Users

In a cognitive radio networks, the users are conventionally classified into two types, namely, PUs and SUs. Due to SUs adopted opportunistic spectrum access strategy, they are required to leave the channels once the PUs reoccupy the channel and handoff to other vacant channels to protect the PUs' transmissions. Therefore, the SUs' transmission can be preempted at any time by the random access of PUs.

Prior researches rarely consider the efficient spectrum handoff for preempted SUs; most of researches avoid dealing with preempted SUs and prefer taking random access channel strategy. In this paper, we treat preempted and new SUs as different priority classes of users. Preempted SUs have higher priority than new ones to access channels but preempted SUs have no preemptive priority to interrupt homogeneous new arrival users. From another perspective, the SUs also can be classified into two types: RT multimedia service and NRT traffics. RT traffics have preemptive priority to interrupt NRT traffics' transmission.

All situations considered, we assume that there are four priority classes of SUs, which are listed in TABEL I. When allocate channels to SUs we should firstly compare preemptive priority then access priority.

B. Spectrum Handoff Strategy with Admission Control

The existing conventional method of spectrum selection is chosen a channel from a set of target channels according to some selection criteria. The detection and selection process are accomplished by SUs themselves independently without decision-making information exchanging. In such a selection process, it is likely that two or more active users try to transmit data over the same channel at the same time which resulted in a collision. Consequently, collision leads to degenerate the system performance. In this paper, we adopted centralized admission control scheme to achieve the goal of prompt information exchange. A CBS will take the place of SUs to scan the entire channel utilization situation periodically and update the candidate set of target channels for SUs. In the proposed scheme, there are high-priority and low-priority buffer queue for SUs. Before the channel assignment, preempted/new RT/NRT users will enter the corresponding queue to waiting for the control information from CBS.

TABLE I
PRIORITIZED CLASSES OF SUS

Classes of SUs	Priority order	
	Preemptive priority	*Access priority*
Preemted RT	High priority	High priority
New arrival RT		Low priority
Preemted NRT	Low priority	High priority
New arrival NRT		Low priority

C. Illustration of Spectrum Handoff Process

In a priority-based CRN, low-priority users have to handoff when high-priority users appeared. The preempted user has to be temporarily broken transmission during the handoff process until a new available channel is discovered and then the unfinished traffic is successfully switched to the new channel. In this paper, the waiting time, includes the handoff delay and channel selection delay, during the handoff process is assumed too short to be neglected. We are more concerned about the completion time T_c which refers to the period from the transmission start till the transmission end. The completion time is mainly consisted of traffic services time T_s and the cumulative delay time T_D during the transmission. A connection of low-priority user might be preempted several times due to the high-priority user intermittent activity on the channels. Fig.1 illustrates an example of spectrum handoff process in the priority-based CRN. As new arrival traffic, it should enter into the corresponding priority queue and wait at the queue tail until all prior users are delivered out. As preempted traffic, it has priority to access channels than new arrival homogeneous traffic so that it will wait in the queue before new arrival traffic. The CBS will preferentially assign available channels to users in the high priority queue then satisfy the demand of low priority queue. In the example, the spectrum handoff process with multiple interrupted can be described as follows:

- At the beginning, a preempted RT traffic resumed transmission at $Ch2$. When a PU appears at the same channel lead to the interruption events happened and the RT traffic was preempted again. According to the information from CBS, the RT traffic will decide the target channels ($Ch1$,... ,Chn).
- The RT traffic switches its operating channel to the idle channel $Ch1$ and resumes the unfinished traffic. The second preempted occurs soon, unfortunately, all the channels were occupied by high-priority users so that there was no target channel for handoff.
- Due to the RT traffic can not execute handoff immediately, it has to enter the buffer queue and waiting for the chance to resume the transmission.
- Finally, the RT traffic completes the transmission until it access channel again at $Ch2$.

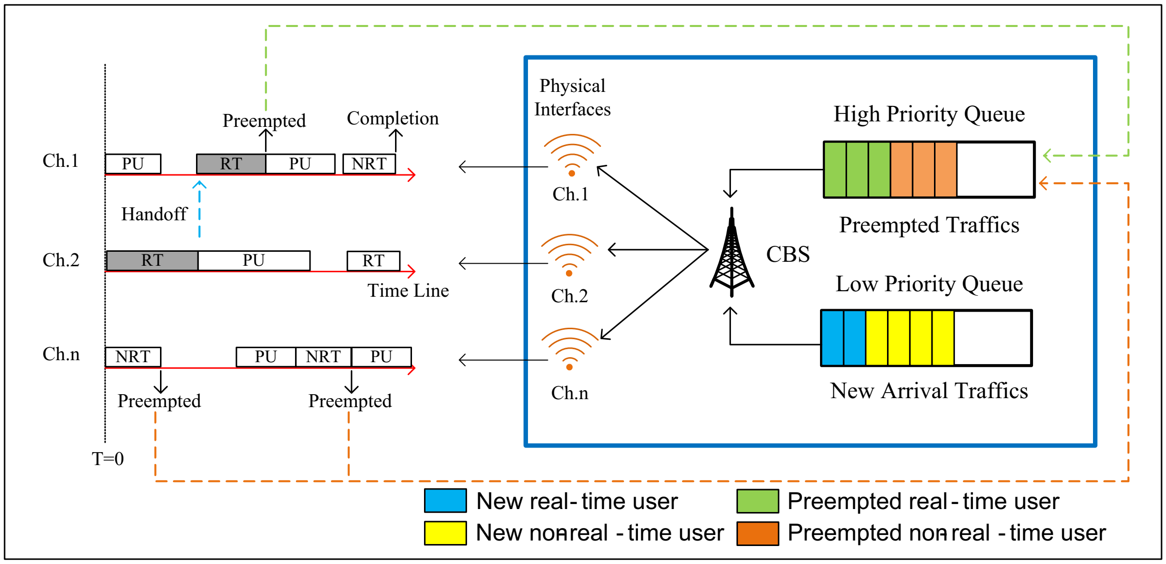

Fig. 1. Illustration of the priority-based CRN architecture

From this example, it shows the biggest differences between the way of always staying on the operating channel and the way of waiting in the buffer queue. The advantage of waiting in the buffer queue is SUs can get service once there are vacant channels in the network. However, the way of always staying means that the waiting users can not resume service even if the other channels were idle.

III. PERFORMANCE EVALUATION

A. System Assumption

In the considered CRN system, we assume that a channel is a basic spectrum resource unit and the spectrum resource is divided into c independent channels. There are two types of users: PUs and SUs. Additionally, the SUs can be subdivided as preempted/new arrival RT/NRT traffics. A PRP M/M/c/c+k queuing model is proposed to characterize the spectrum utilization where $c+k$ is the waiting positions in the buffer queue for preempted and new arrival SUs. The key features of the proposed PRP M/M/c/c+k queuing model are as follows:

- Each channel can service one user at any time.
- For the sake of preemptive resume priority (PRP) discipline, the high priority class of users has the right to preempt the low priority class of users.
- The preempted users can resume unfinished transmitssion at any available channel instead of stay at the prior operating channel.
- The arrival of PUs, RT multimedia service and NRT traffics follow the Poisson process with mean rates of λ_p and λ_{nrt}; and the service time is an exponentially distribution random variable with mean rates of μ_p^{-1}, μ_{rt}^{-1} and μ_{nrt}^{-1}.

B. Analytical model for spectrum handoff with finite buffer

This system is formulated as a PRP M/M/c/c+k queuing model. We assume that there are c channels provided to all users to transmit and $c+k$ waiting positions for preempted users to maintain unfinished work and new arrival users to waiting for vacant channels. In fact the CRN system can load a maximum number of $2c+k$ users. But we just allowed $c+k$ SUs enter into the buffer queue at the same time otherwise SUs will be blocked. The advantage of this principle is even if all the channels were occupied by PUs there is sufficient space to store the preempted SUs instead of force terminate the on-going transmission. Let $S(i_p, i_{rt}, i_{nrt}; j_p, j_{rt}, j_{nrt})$ represents the system state, simplified as S, where i_p, i_{rt} and i_{nrt} represent the number of PU, RT and NRT traffics in the system; Similarly, j_p, j_{rt} and j_{nrt} represent the number of PU, RT and NRT traffics currently on-going over channels, respectively. For a valid state space Ω should satisfy the following conditions:

$$\Omega = \{S(i_p, i_{rt}, i_{nrt}; j_p, j_{rt}, j_{nrt}) \mid i_p \le c; i_{rt} + i_{nrt} \le c+k;$$
$$j_p + j_{rt} + j_{nrt} \le c; j_p = i_p;$$
$$j_{rt} = \min c - j_p, i_{rt}; j_{nrt} = \min c - j_p - j_{rt}, i_{nrt}\}$$

It is noteworthy that in the state the number of on-going services $j_m, m = (p, rt, nrt)$ always can be expressed by the total number of traffics in the system $i_m, m = (p, rt, nrt)$. Due to the preemptive nature of priority, when there is a high-priority customer in the system, it will be in service. In other words, the channel resources have to meet demand of highest priority customer firstly; then satisfy the closely followed priority customer. The on-going services of PUs will always occupy same amount of channels $j_p = i_p$. The secondary priority class of RT multimedia service can access channels if there are RT in the system and the number of channels used by PUs is less

TABLE II
DEFINITIONS OF SYMBOLS

Symbols	Definitions
$i_{p/rt/nrt}$	The total number of PU/RT/NRT accessed in the system.
$j_{p/rt/nrt}$	Number of on-going PU/RT/NRT.
π_s	The probability of state $S(i_p, i_{rt}, i_{nrt}; j_p, j_{rt}, j_{nrt})$
Ω	The set of feasible state in Markov model.
φ_s	An indicator function of state S if S belong to Ω
c and k	Number of channels and the size of buffer queue.
$T^{s(i_p)}_{s^{'}(i_p+1)}$	State transmission rate for $S^{'}(i_{p-1}) \Rightarrow S(i_p)$
$S(i_p, i_{rt}, i_{nrt}; j_p, j_{rt}, j_{nrt})$	The state of channel and buffer utilization.

than c so we can get the equation $j_{rt} = min(c - j_p, i_{rt})$. For the same reason, $j_{nrt} = min(c - j_p - j_{rt}, i_{nrt})$. Let π_s be the steady state probability distribution for the state $S \in \Omega$. In order to simplify the balance equation, we introduce an indicator function φ_s be equal to one if the state $S \in \Omega$, and zero otherwise. A quick reference of some symbols with descriptions frequently used in this paper is given in TABLE II.

The transitions for state $S(i_p, i_{rt}, i_{nrt}; j_p, j_{rt}, j_{nrt})$ are explained by using Fig.2. For convenience, a simplified representation for system state was introduced. For example $S(i_p, i_{rt}, i_{nrt}; j_p, j_{rt}, j_{nrt}) \Rightarrow S^{'}(i_p, i_{rt}, i_{nrt}; j^{'}_p, j^{'}_{rt}, j^{'}_{nrt})$ equally expressed as $S(i_p) \Rightarrow S^{'}(i_{p+1})$. The system dynamics are triggered by the following events:

1) *PU arrival*. There are two situations for a PU arrival.
    - $S(i_p) \Rightarrow S^{'}(i_{p+1})$, $T^{s(i_p)}_{s^{'}(i_p+1)} = \varphi_{s^{'}(i_p+1)}\lambda_p$ where $\varphi_{s^{'}(i_p+1)}$ indicate that the $s^{'}(i_p+1) \in \Omega$
    - $S^{'}(i_{p-1}) \Rightarrow S(i_p)$, $T^{s^{'}(i_p-1)}_{s(i_p)} = \varphi_{s^{'}(i_p-1)}\lambda_p$
2) *PU departure*. There are two situations for PU departure.
    - $S(i_p) \Rightarrow S^{'}(i_{p-1})$, $T^{s(i_p)}_{s^{'}(i_p-1)} = \varphi_{s^{'}(i_p-1)} j_p \mu_p$
    - $S^{'}(i_{p+1}) \Rightarrow S(i_p)$, $T^{s^{'}(i_p+1)}_{s(i_p)} = \varphi_{s^{'}(i_p+1)} j^{'}_p \mu_p$
3) *RT multimedia service arrival*. There are two situations for a RT multimedia service arrival.
    - $S(i_{rt}) \Rightarrow S^{'}(i_{rt+1})$, $T^{s(i_{rt})}_{s^{'}(i_{rt}+1)} = \varphi_{s^{'}(i_{rt}+1)}\lambda_{rt}$
    - $S^{'}(i_{rt-1}) \Rightarrow S(i_{rt})$, $T^{s^{'}(i_{rt}-1)}_{s(i_{rt})} = \varphi_{s^{'}(i_{rt}-1)}\lambda_{rt}$
4) *RT multimedia service completion*. There are two situations for a RT multimedia service completion.
    - $S(i_{rt}) \Rightarrow S^{'}(i_{rt-1})$, $T^{s(i_{rt})}_{s^{'}(i_{rt}-1)} = \varphi_{s^{'}(i_{rt}-1)} j_{rt} \mu_{rt}$
    - $S^{'}(i_{rt+1}) \Rightarrow S(i_{rt})$, $T^{s^{'}(i_{rt}+1)}_{s(i_{rt})} = \varphi_{s^{'}(i_{rt}+1)} j^{'}_{rt} \mu_{rt}$
5) *NRT traffic arrival*. There are two situations for a NRT traffic arrival.
    - $S(i_{nr}) \Rightarrow S^{'}(i_{nr+1})$, $T^{s(i_{nr})}_{s^{'}(i_{nr}+1)} = \varphi_{s^{'}(i_{nr}+1)}\lambda_{nr}$
    - $S^{'}(i_{nr-1}) \Rightarrow S(i_{nr})$, $T^{s^{'}(i_{nr}-1)}_{s(i_{nr})} = \varphi_{s^{'}(i_{nr}-1)}\lambda_{nr}$
6) *NRT traffic departure*. There are two situations for a NRT traffic arrival.
    - $S(i_{nr}) \Rightarrow S^{'}(i_{nr-1})$, $T^{s(i_{nr})}_{s^{'}(i_{nr}-1)} = \varphi_{s^{'}(i_{nr}-1)} j_{nr} \mu_{nr}$
    - $S^{'}(i_{nr+1}) \Rightarrow S(i_{nr})$, $T^{s^{'}(i_{nr}+1)}_{s(i_{nr})} = \varphi_{s^{'}(i_{nr}+1)} j^{'}_{nr} \mu_{nr}$

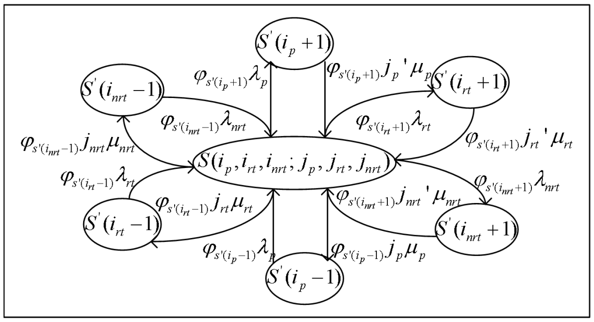

Fig. 2. State transitions from/to state S

On the basis of trigger events analysis, we developed the global balance equation as:

$$\left[\sum\nolimits_{m=\{p,rt,nr\}} T^{s(i_m)}_{s^{'}(i_m+1)} + \sum\nolimits_{m=\{p,rt,nr\}} T^{s(i_m)}_{s^{'}(i_m-1)}\right] \pi_s \varphi_s$$
$$= \sum\nolimits_{m=\{p,rt,nrt\}} T^{s^{'}(i_m+1)}_{s(i_m)} \pi_{s^{'}(i_m+1)} +$$
$$\sum\nolimits_{m=\{p,rt,nrt\}} T^{s^{'}(i_m-1)}_{s(i_m)} \pi_{s^{'}(i_m-1)} \tag{1}$$
$$\sum\nolimits_{\{S(i_p,i_{rt},i_{nrt};j_p,j_{rt},j_{nrt})\in\Omega\}} \pi_s = 1 \tag{2}$$

We can obtain the steady-state probability by solving the global balance equation.

C. Average completion time of RT multimedia service

In this part, we will focus on the analysis of the completion time T_c of RT multimedia service, which is a meaningful performance metric for delay-sensitive traffic. In an ideal case, the RT traffic completes transmission during a continual period without any interruption. However, during the transmission process may encounter multiple interruptions from PUs which is mainly contributed to the cumulative delay. We introduce two i.i.d random variables T_s and T_D denote the service time and the cumulative delay respectively. In this paper, we neglect the handoff time hence the completion time consists of service time and the cumulative delay. Then, the expectation of completion time can be expressed as:

$$E[T_c] = E[T_s] + E[T_D] \tag{3}$$

We assume T_s follows the exponential distribution with mean of μ_{rt}^{-1}. Even if traffics encounter interruption, the remainder service time T_s^R still follows the same distribution because of the memoryless property. So that the expectation of service time can be divided into two parts:

$$E[T_s] = E[X_s] + E[T_s \mid H = n] P(H = n) \tag{4}$$

Where $E[X_s] = \mu_{rt}^{-1}$ denotes the mean service time without interruption; and $E[T_s|H = n]$ denotes the mean service time of transmission surfer from n times interruptions. $E[T_s|H = n] = \sum_{i=1}^{n} (T_s^R)_{(i)}$ is erlang distribution with mean of $n\mu_{rt}^{-1}$.$P(H = n)$ is the probability of service encounter n times interruptions. The probability of RT multimedia service encounters the interruption is given by:

$$P_r = \frac{\sum_{\{S|j_p+j_{rt}=c\}} \frac{1}{j_{rt}} \pi_s}{\sum_{\{S|j_{rt}>0\}} \pi_s} \tag{5}$$

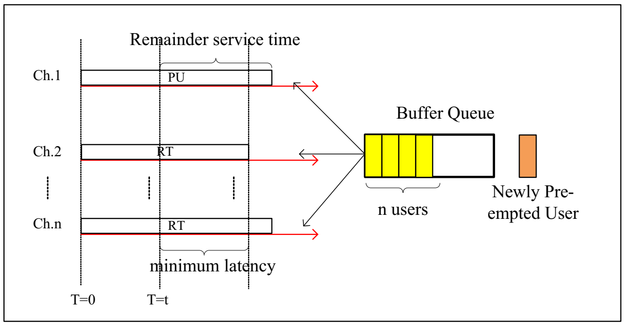

Fig. 3. Waiting delay for preempted RT traffic

During the RT transmission period, each PU arrival events may lead to the RT preempted by the mean probability of P_r. Once the RT traffic was preempted means it has to enter into the buffer to suspend the service. We denote the P_{pre} represents the probability of preempted events deduced as:

$$P_{pre} = \frac{\lambda_p P_r}{\mu_{rt} + \lambda_p P_r} \tag{6}$$

Then

$$P(H = n) = P_{pre}^n \tag{7}$$

Without loss of generality, we consider a preemption case shown in Fig.3. A newly preemptive event arrival at $T = t$, at this moment there are m prior users in the buffer queue and all the channels are occupied. According to the admission control strategy, the head-of-line user can get service if any users complete transmission and departure the channel. We denote the minimum latency for the head-of-line as T_{min} where $T_{min} = min\{T_s^{R(1)}, T_s^{R(2)}, , T_s^{R(n)}\}$ is submitted to minimum distribution. If $T_s^{R(i)}$ represents the remainder service time of PUs or RT traffics at channel i. $F_i(t)$ represents the CDF of remainder service time. Then, we can get the CDF of minimum latency $T_{min}(t) = 1 - [1 - F_1(t)][1 - F_2(t)][1 - F_n(t)]$ and the expectation of T_{min}, $E[T_{min}] = \int_0^\infty td[T_{min}(t)]$. For the $m + 1$ preempted user, the delay time T_d is given by

$$E[T_d] = (m + 1)E[T_{min}] \tag{8}$$

For the n^{th} preempted users, the cumulative delay time is express as

$$E[T_D] = \sum_{n=1}^{\infty} E[T_d|H = n]P(H = n) \tag{9}$$

D. Performance Analysis

In this part, we will study the performance metrics of different priority classes of users according to their special characteristics. For the system performance, the blocking probability and throughput are key measurement metrics. For NRT traffic, we are more concerned with the throughput capacity rather than the delay time. Due to the delay-sensitive feature, the average completion time is the most intuitive metric to evaluate the performance of RT traffic.

1) *Blocking probability of SUs*. The blocking event will happen when the number of SUs in the system is equal to $c + k$, thus, blocking probability is given by

$$P_b = \sum_{\{S(i_p, i_{rt}, i_{nrt}; j_p, j_{rt}, j_{nrt}) | i_{rt} + i_{nrt} = c + k\}} \pi_s \tag{10}$$

2) *The throughput of SUs and NRT traffic*. It is defined as the average number of completed service for traffic per second.

$$\rho = \sum_{\{S \in \omega\}} j_{rt} \mu_{rt} \pi_s + \sum_{\{S \in \omega\}} j_{nrt} \mu_{nrt} \pi_s \tag{11}$$

$$\rho_{nrt} = \sum_{\{S \in \omega\}} j_{nrt} \mu_{nrt} \pi_s \tag{12}$$

3) *The average completion time of RT multimedia service*. Substituting $(4) - (9)$ into (3), we can obtain the closed-form expression for the completion time:

$$E[T_c] = \mu_{rt}^{-1} +$$
$$\textstyle\sum_{n=1}^{\infty} [n\mu_{rt}^{-1} + n(m + 1) \int_0^\infty td[T_{min}(t)](\frac{\lambda_p P_r}{\mu_{rt} + \lambda_p P_r})^n$$

IV. NUMERICAL RESULTS

In this section, the simulation and numerical results are presented to evaluate the performance of proposed scheme. We will compare three types of scheme: 1. without buffer mechanism scheme (WOB). In this scheme, new arrival users will be blocked directly and preempted users will be dropped. 2. without priority scheme (WOP). We assume that all of the SUs in this scheme follow First Come First Serve (FCFS) scheduling policy. 3. Proposed scheme with priority and buffer mechanism (WPB). In our simulation experiment, we use the following parameters: $c = 3, k = 2, \lambda_p = 0.2, 0.3, , 1.1, 1.2, \lambda_{rt} = 1.8, \lambda_{nrt} = 1.5, \mu_p^{(-1)} = 1.8, \mu_{rt}^{(-1)} = 2, \mu_{nrt}^{(-1)} = 1.4$. The simulation time is 10 000s.

As show in Fig.4 and Fig.5, we compare the throughput of SUs and NRT traffics under these three different schemes. In both figures, the throughput of SUs, NRT traffics as one kind of SUs, will decrease slowly with the increase of PUs arrive rate. This is because the more frequently the PUs access the less efficiency of channel utilization for the SUs. Even the PUs arrive rate remains the same, the proposed scheme over performance than the other two schemes. In other words, the WPB reach the largest throughput and the WOB has the minimum throughput among these three schemes. This result indicates that the buffer mechanism work well in the function of maintain the SUs handoff request which indirectly improve the throughput. Fig.6 shows the average completion time of RT traffic. Because the FCFS rule cause the longer waiting time for the RT traffics, the scheme without priority has the longest completion time among these schemes. The proposed scheme with prioritized SUs can shorten completion time obviously. However, the blocked and preempted users will not add into the statistic samples in the scheme without buffer so that the completion time almost equal to the service time of RT traffics. Fig.7 shows the blocking probability of SUs. We can

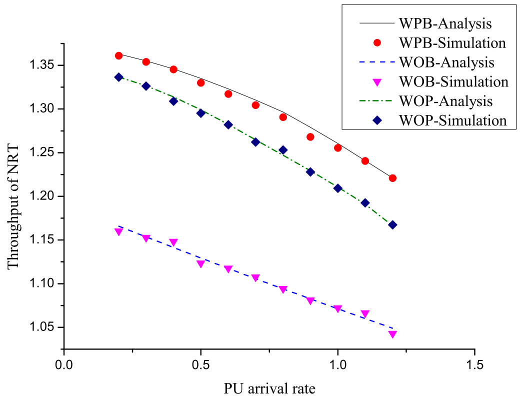

Fig. 4. Throughput of NRT traffics

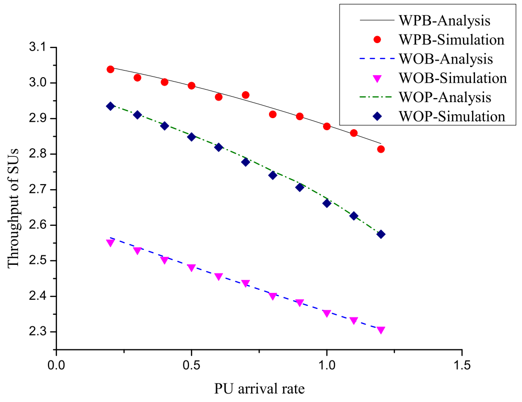

Fig. 5. Throughput of SUs

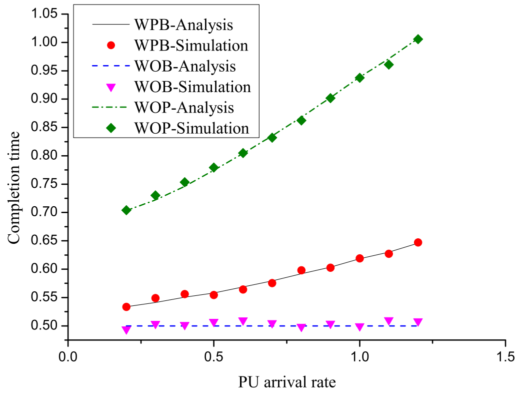

Fig. 6. Blocking probability of SUs

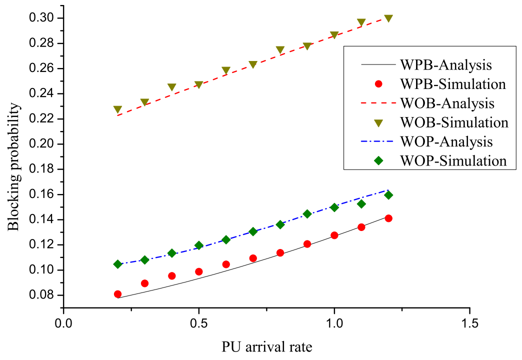

Fig. 7. Completion time of RT traffics

see that the schemes with buffer have significant low blocking probability than the scheme without buffer which is intuitively understandable. Due to the prioritization, the proposed scheme can further reduce the blocking probability than the scheme without priority.

V. CONCLUSION

In this paper, we proposed a prioritized spectrum handoff scheme with buffer mechanism to improve the performance of multimedia transmission in CRN. The proposed scheme gives preference for preempted users and protects the SUs from force termination. A PRP M/M/c/c+k queue model is established to analysis the scheme. We have derived the blocking probability, the throughput of SUs and NRT traffic and the completion time of RT traffic. The analytical results have been confirmed through simulation.

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