

## Research on Key Technologies of Dynamic Spectrum Access in Cognitive Radio

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### **Abstract**

*Research on spectrum sensing and spectrum switching that are the key technologies of cognitive radio dynamic spectrum access is carried out in this paper. In order to reduce the required number of dualistic detection when in low spectrum occupancy rate and reduce the complexity of wideband spectrum sensing calculation, this paper presents a wideband spectrum sensing method based on group testing (GT) and constructs a two-step GT scheme based on polyphase filtering. In terms of spectrum switching, a method based on spectrum prediction is proposed for the determination of the switching time. Test results show that the main function of dynamic spectrum access is changed into reality. Both sides of the cognitive radio test platform could automatically find the idle channel link and establish links without common control channel, furthermore, when the current communication channel is reoccupied by primary users, the platform could switch to other idle channel automatically and quickly.*

**Keywords:** *Cognitive radio; Dynamic spectrum access; Spectrum sensing; Spectrum switching cognitive radio*

### **1. Introduction**

Wireless spectrum is a kind of precious natural resources. The fixed spectrum allocation mechanism designated by the government supervision institution leads to the low utilization rate of the spectrum. In order to improve the spectrum utilization, the cognitive radio technology is proposed to dynamically use the spectrum holes which are not used by authorized users for the time being. This spectrum usage is also known as dynamic spectrum access. Dynamic spectrum access is a kind of independent, dynamic and efficient spectrum usage, which has important significance to alleviate the spectrum resource tension and improve the spectrum utilization [1].

However, the implementation of dynamic spectrum access needs to solve a series of difficult problems, including spectrum sensing, spectrum switching and so on. Based on the solutions to several key problems in cognitive radio dynamic spectrum access this paper focuses on wideband radio spectrum sensing and spectrum handoff technology which can provide the basis of algorithm for the practical application of dynamic spectrum access in cognitive radio.

### **2. Nyquist Broadband Spectrum Sensing Based on GT**

Wideband spectrum sensing is a basic premise of cognitive radio dynamic spectrum access. The purpose of wideband spectrum sensing is to find the spectrum holes that are not occupied by the primary users from the sensing frequency band. These spectrum holes are the idle channels which are expected to be used by cognitive radio [2].

The purpose of GT is to find defective set from a series of items set with detection times as little as possible. This method is widely used in the detection of syphilis for soldiers during World War II. According to the traditional detection method, detection times depend on the number of soldiers, but GT is not. According to the GT method, soldiers' blood samples were mixed and then used for detection. If the result is negative, all the soldiers in the mixing pool were negative; otherwise, the soldiers in the mixing pool need to be tested one by one. As the number of syphilis positive soldiers is much less than the number of soldiers, so this method greatly reduces the total number of detection. Since then, GT has been widely used in many fields: HIV detection, DNA library Screening, product quality control, data compression, storage system file search, sensor network data collection, multiple access communication and so on. Taking each channel in broadband as items and the channel contains the main user as GT seconds; the spectrum sensing process is transformed to how to design the various pools to reduce the number of dualistic detection [3].

## 2.1. General Method of Wideband Spectrum Sensing

Set  $x_i(n)$  for the complex baseband signals of the first  $i$  channel. Let  $O(I, J)$  be the first  $(I, J)$  elements in the observation matrix  $O$ , we get the signals for the first  $J$  pool as below:

$$g_j(n) = \sum_{i=1}^N x_i(n) O_{(i,j)} \quad (1)$$

By detecting whether  $g_j(n)$  contains signals can complete the detection of the original signals  $x_i(n)$ . If the dualistic detection method is ideal, the detection model according to formula (1) will be completely matched with GT, consequently, the existing GT method can be used to complete the wideband spectrum sensing. If the test adopts the two-step GT method above and meets the condition for  $M_{GT} = \lceil N / \lfloor \log 2 / P \rfloor \rceil \lceil \log P / \log 2 \rceil$ , in which,  $P$  articles for the probability of defective products,  $\lceil a \rceil$  refers to the smallest integer greater than or equal to  $a$ ,  $\lfloor a \rfloor$  presents the greatest integer less than or equal to  $a$ , formula (2) can be defined as follows:

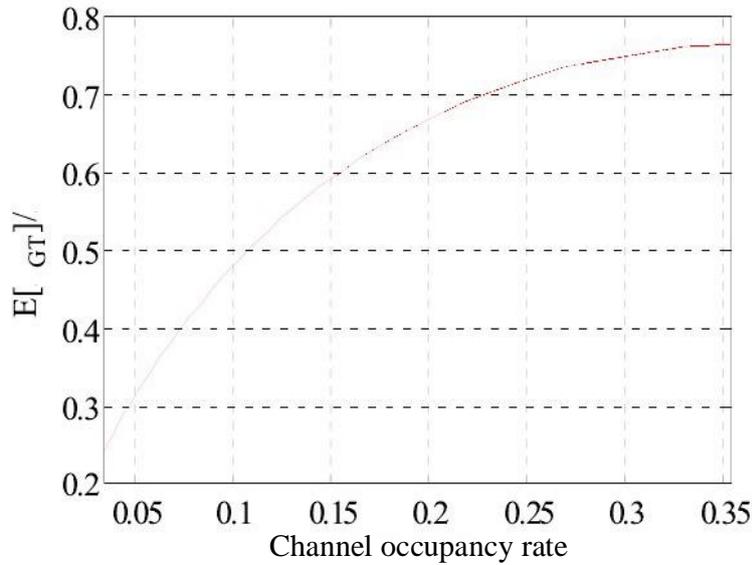
If  $p = N^{-\beta}$  and  $\beta \in (0, 1/2)$ , then:

$$\lim_{N \rightarrow \infty} \frac{E[L_{GT}]}{\beta p N \log N} = \frac{1}{(\log 2)^2} \quad (2)$$

Where  $L_{GT}$  expresses the number of detection, and  $E[L_{GT}]$  indicates the mathematical expectation of  $L_{GT}$ .

Figure 1 shows the curve of the ratio of  $E[L_{GT}]$  to  $N$  with the change of channel occupancy rate, where  $N=1000$ . As seen in the figure, when the channel occupancy rate is low, the two-step GT method can greatly reduce the total detection times of the broadband spectrum sensing and reduce the computational complexity [4].

It should be noted that the above mentioned method in formula (1) is shown to be applicable only if the signals of each channel have been acquired. This section will then put forward a realization method based on polyphase filter, which combines signals acquisition process with GT pool construction processes, so as to further reduce the computational complexity [5].



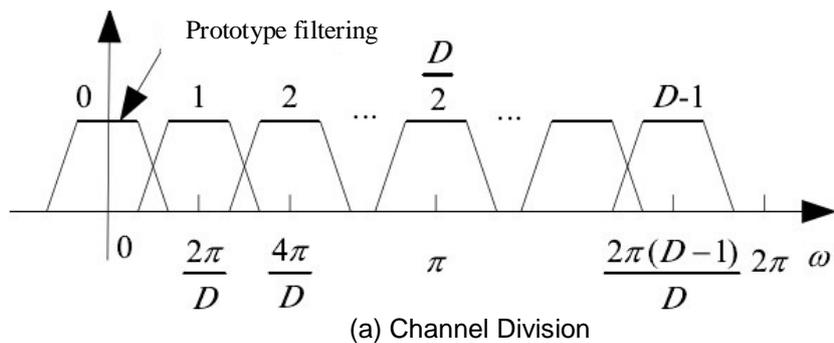
**Figure 1. Average Detection Times**

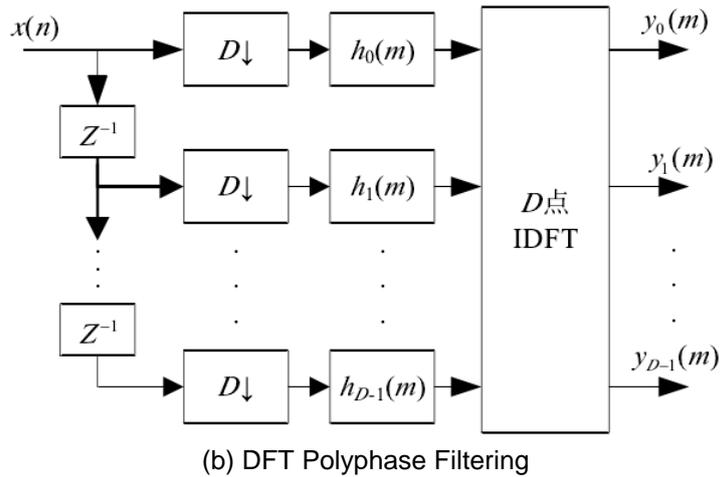
**2.2. Realization Method Based on Polyphase Filtering**

Based on the idea of GT, this paper proposes a two-step implementation method In view of polyphase filtering. The realization of the filter bank are usually based on the prototype filter  $h(n)$ . Prototype filter  $h(n)$  is a low pass filter, which is usually used as the zeroth sub filter of a filter bank, and its frequency shift can form other sub band filter as shown in Figure 2 (a). A classical implementation of the filter bank is a Polyphase Filter Bank named DFT, which is shown in Figure 2 (b). In figure 2 (b),  $h_p(n)$ , which equals to  $h(mD+p)$ , is the polyphase component of  $h(n)$ . The most attractive features of PFB is its low computational complexity, which is the equivalent of the accumulation of computation complexity degree of  $h(n)$  and the discrete Fourier inverse transform calculation of length  $D$ . In the computation process,  $D$  is the number of divided channels, which will be called the number of sub bands in the following. One of the disadvantages of the classical DFT PFB is that according to its channel division (as seen in Figure 2 (a)), the first  $D/2$  sub band will contain non continuous frequency components when the input signal is a complex signal. The specific frequency components are calculated according to the following formula:

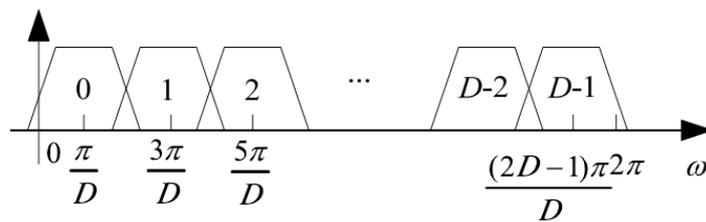
$$(-f_s/2, -f_s/2 + B_s/2] \cup [f_s/2 - B_s/2, f_s/2)$$

Where  $f_s$  is the sampling frequency and  $B_s$  is sub band bandwidth. In order to solve this problem, this paper uses the polyphase filtering proposed by Yang Xiaoniu, the channel division mode is shown in Figure 3 (a). In this way, all the output sub bands have the same bandwidth, and they both contain continuous frequency component.

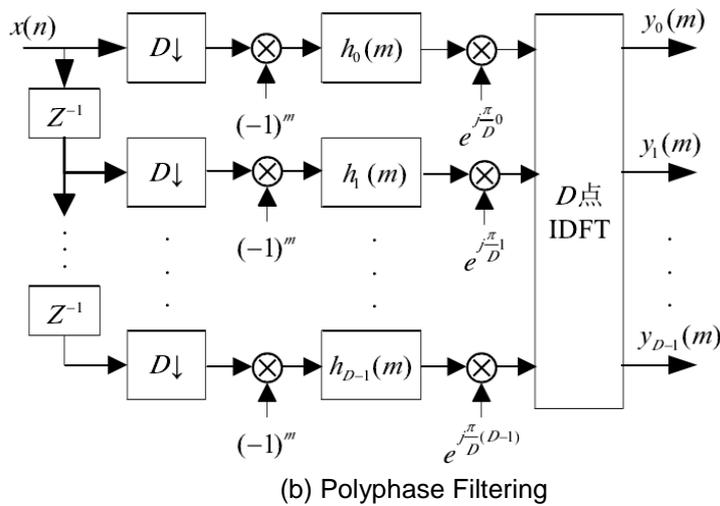




**Figure 2. Classical DFT Polyphase Filtering**



(a) Channel Division



**Figure 3. Improved DFT Polyphase Filtering**

After extraction, the band pass filtered signals, which are  $w_k$ -centered, can be expressed as:

$$\begin{aligned}
 y_k(m) &= \left\{ (x(n)e^{-j\omega_k n}) * h(n) \right\} \Big|_{n=mD} \\
 &= \left\{ \sum_{i=-\infty}^{+\infty} (x(n-i)e^{-j\omega_k(n-i)}) \cdot h(i) \right\} \Big|_{n=mD} \\
 &= \sum_{p=0}^{D-1} \sum_{i=-\infty}^{+\infty} (x(mD-iD-p)e^{-j\omega_k(mD-iD-p)}h(iD+p))
 \end{aligned} \tag{3}$$

Assume that  $x_p(m) = x(mD - p)$  and  $h_p(m) = h(mD + p)$ , bringing A and B into formula(3), the following formula can be obtained:

$$\begin{aligned}
 y_k(m) &= \sum_{p=0}^{D-1} \left( (x_p(m)(-1)^m) * h_p(m) \right) e^{j\frac{\pi}{D}p} e^{j\frac{2\pi}{D}kp} \\
 &= D \cdot IDFT \left[ \left( (x_p(m)(-1)^m) * h_p(m) \right) e^{j\frac{\pi}{D}p} \right]
 \end{aligned}
 \tag{4}$$

The direct applying of formula (4) can get a new PFB, as shown in Figure 3 (b). Note that in the calculation of IDFT, ignoring constant D. Since the multiplication with  $(-1)^m$  can be achieved by additive and the multiplication with  $\exp(j\pi p/D)$  can be integrated into  $h_p(m)$  in advance, this new calculation complexity of PFB is comparable with traditional methods [6].

### 2.3. Wideband Spectrum Sensing Based on Two Stage Polyphase Filtering

This paper uses Two-stage polyphase filtering as an implementation of two-step GT method. The first stage of polyphase filtering is used to achieve the first step of GT, and the second stage polyphase filtering is used to achieve the second step of GT.

The first grade PFB uses the form which contains  $D_1$  channels (sub bands), as Figure 4 shows, the output of each channel contains  $D_2$  channels.  $D_1$  and  $D_2$  are integers and satisfy the condition for  $2 \leq D < N$  and  $D_1 D_2 = N$ . In this paper, the follow-up PFB is called PFB1. The input of PFB1 is  $x_b(n)$  which can be obtained in the following manner. First, the RF front end filter is used to filter out the frequency band  $[F_1, F_2]$ , then the signals are mixed into an intermediate frequency, finally, the signals are sampled. The sampled signals are defined as  $x(n)$ . Processing  $x(n)$  by digital frequency conversion, half band filter and extraction, then the baseband signal  $x_b(n)$  is obtained. For a simple representation, this paper assumes that the coverage of the  $x_b(n)$  is frequency band  $[f_1, f_2]$ . (In fact, due to the impact of the analog filter transition band, the coverage of frequency band of  $x_b(n)$  is wider than  $[f_1, f_2]$ . This problem can be solved by increasing the number of first phase of filter channel.)

As a result, the output of each channel of PFB1 exactly contains the signals of the  $D_2$  channel, which can be regarded as a pool of GT. After polyphase filtering, the output of each channel is detected by the dualistic detection method. Regard  $\mu_i$  ( $1 \leq i \leq M_1$ ) as the detection results of the first  $i$  channel. If  $\mu_i$  equals to 0, all  $D_2$  channels are idle, otherwise, the second phase filter for further detection is required. In the first stage, the number of dualistic detection is  $D_1$ .

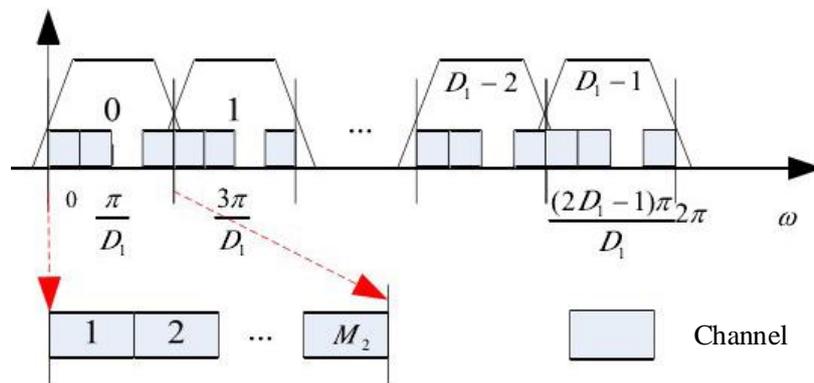


Figure 4. The First Level PFB

The Second stage polyphase filtering judges the output of the first stage of the polyphase filter as the channel of containing signals, which contains the number of channels is  $D=D_2$ . In the following this multiphase filter is called PFB2. The input of PFB2 is the output sub band signals of PFB1. Similarly, use the same dualistic detection method for the judgment of the output of PFB2. Each PFB2 requires  $D_2$  times of dualistic

detection, so a total of  $k$   $D_2$  times of dualistic detection are needed in the second stage.  $K$  presents the number of elements in set  $i$ , in which  $\mu_i=1$ .

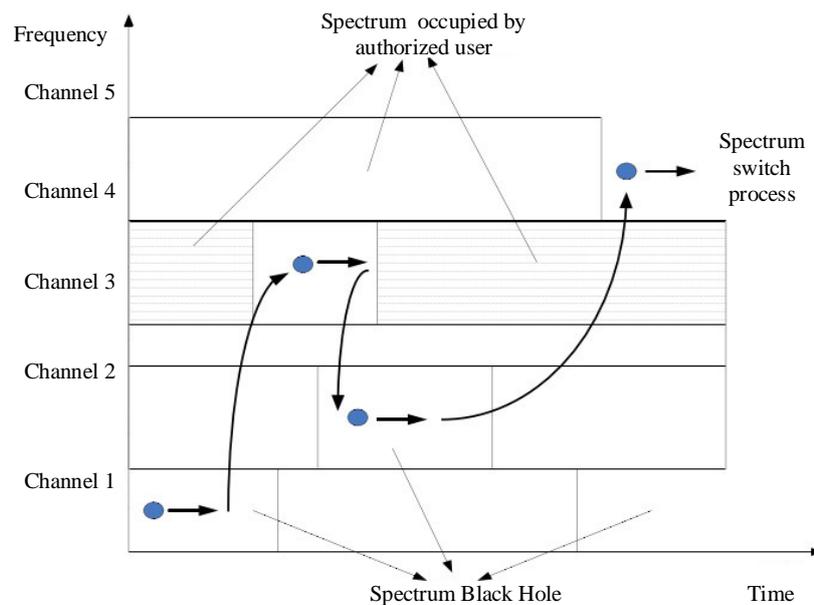
Assumption that the probability of the channel occupied by the main user is  $P$ , with the above two phase filter detection method, the average number of dualistic detection can be defined as [7]:

$$E[L_{GT}] = D_1 + N(1 - (1 - p)^{D_2}) \quad (5)$$

Due to the low utilization rate of the current wireless spectrum, it is expected to set up a high probability for  $E[L_{GT}] < N$ , thus the number of dualistic detection can be reduced so as to the computational complexity.

### 3. Cognitive Radio Spectrum Switching

Spectrum switching is a process of changing the running frequency of cognitive users in the process of communication. Different from the existing fixed spectrum allocation method, as shown in Figure 5, the cognitive user in cognitive radio networks communicate by "renting" the temporary appearance of spectrum holes. Therefore, the cognitive user is selecting the most suitable band in a dynamic scene. When converting the current communication frequency band, spectrum switching can maintain uninterrupted communication services.

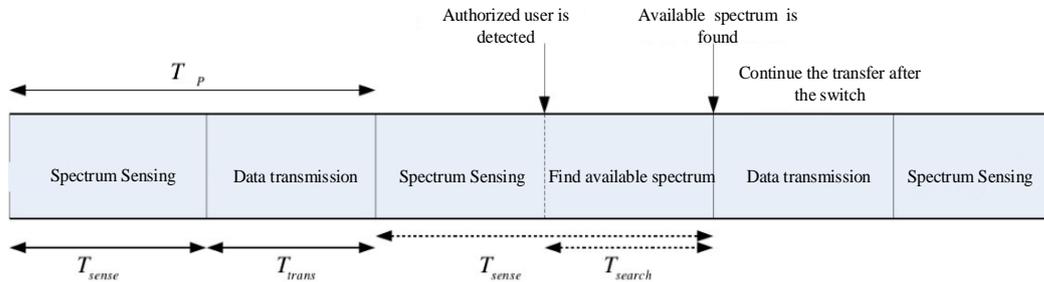


**Figure 5. Spectrum Switching**

#### 3.1. Spectrum Detection and Handoff Prediction

The cognitive users in the communication process must be periodically sensing signal intensity. The length of the sensing cycle which affects usage efficiency of the cognitive user also requires specific consideration of the frequency of the authorized users using the authorized channel. Cognitive users usually need a wide range of spectrum testing. Because of the constraints of large number of channels, detection time and detection energy, continuous detection can't be achieved in the whole frequency band. So the cognitive user can debate the range of spectrum sensing by the choice of spectrum, thereby reducing the switching delay.

Aiming at the goal of maximizing the spectrum utilization, the optimization algorithm of the sensing period is proposed. But in these articles, the QOS needs of cognitive users and the frequency of channel usage of authorized users are not considered. An effective solution is to enhance the tracking, learning and updating of idle spectrum, by intelligently selecting the optimal channel sensing set, as shown in Figure 6, to achieve the goal of reducing  $T_{search}$  while reducing the power consumption [8].

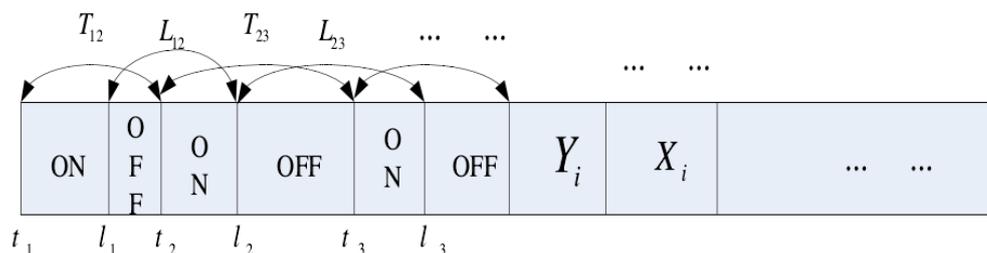


**Figure 6. Perception and Transmission Cycle**

It is an effective solution for cognitive users to perceive patterns in real time without the rules of authorized user behavior. The premise of cognitive radio is that it can't affect the normal activities of authorized users, so more and more researches tend to be arranged in advance of the switching process. Under the dynamic spectrum circumstance, forming a regular record of behavior model of authorized user on the channel through the periodicity detection of current spectral can help make accurate prediction of the availability of future spectrum and realize the pre evaluation of switching time. However, it is possible to perform handoff in each communication slot by using the switching scheme in the paper, thus the function of spectrum prediction can't be fully used. Activities of authorized users can also be modeled as Communication service model which meets the Irish distribution and uses methods based on transfer probability selection and reliability method to perform spectrum switching automatically. However, it has to wait to switch until the expiration of the service life of the local channel, and switching not in time will cause some interference to licensed users.

### 3.2. Spectrum Prediction Method

#### 3.2.1. Maximum Likelihood Estimation of Rate Parameters:



**Figure 7. The Active State of the Authorized User Observed by the Cognitive User**

As shown in Figure 7,  $x_i$  shows the off state duration of two communication nodes, A and B,  $y_i$  indicates the on state duration of two communication nodes, A and B. In the picture,  $t_1, t_2$  express the arrival time of authorized users,  $T_{12}, T_{23}$  represent time intervals between two times of occupying licensed spectrum of authorized users,  $l_1, l_2$  imply the leave time of authorized users,  $L_{12}, L_{23}$  refer to time intervals between two times of not occupying licensed spectrum of authorized users.

After a period of observation, cognitive users have stored a certain amount of activity information of authorized user and summed up that the authorized user's activity rules meet negative exponential distribution, and then it becomes necessary to estimate the rate parameter of negative exponential distribution. The channel time occupied by authorized users is continuous and asymptotically unbiased, so the maximum likelihood estimation method is adopted to gradually approach the true value and increase the accuracy of the prediction results with updating on the rate parameter estimates in real-time.

Firstly, calculating the maximum likelihood function of the rate parameters of the OFF state duration as follows:

$$L(\lambda_{OFF}) = \prod_{i=1}^n \lambda_{OFF} e^{-\lambda_{OFF} x_i} = \lambda_{OFF}^n e^{-\lambda_{OFF} \sum_{i=1}^n x_i} \quad (6)$$

Secondly, taking logarithm to the function above:

$$\ln L = n \ln \lambda - \lambda \sum_{i=1}^n x_i \quad (7)$$

Finally, seeking the derivative of the log deformation of likelihood function:

$$\frac{d \ln L}{d \lambda} = \frac{n}{\lambda} - \sum_{i=1}^n x_i = 0 \quad (8)$$

The maximum likelihood estimate of the rate parameter of authorize user OFF state duration,  $x_i=(x_1, x_2, \dots, x_n)$ , from cognitive user is as follows:

$$\hat{\lambda}_{OFF} = \frac{1}{\bar{x}} \quad (9)$$

Similarly, the maximum likelihood estimate of the rate parameter of authorize user ON state duration,  $y_i=(y_1, y_2, \dots, y_n)$ , from cognitive user is as follows:

$$\hat{\lambda}_{ON} = \frac{1}{\bar{y}} \quad (10)$$

### 3.2.2. Calculation of Free Probability of Spectrum:

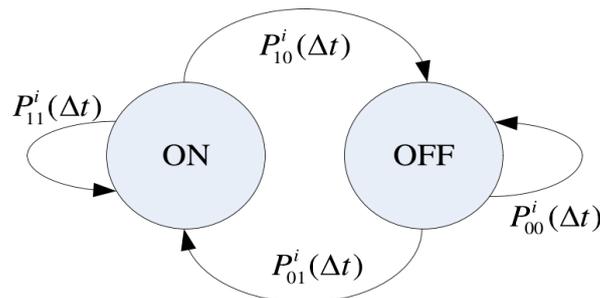


Figure 8. ON/OFF State Transition Diagram

Referring to Figure 8, according to the update theory and combine with the last section, the probability of authorized users change state from 0 to 0 and from 1 to 0 states is respectively described below:

$$\begin{aligned} P_{00}^i &= 1 - \eta_i + \eta_i \cdot e^{-(\lambda_{ON} + \lambda_{OFF}) \Delta t} \\ P_{10}^i &= 1 - \eta_i - (1 - \eta_i) e^{-(\lambda_{ON} + \lambda_{OFF}) \Delta t} \end{aligned} \quad (11)$$

Where  $\Delta t$  is a time interval from one perception slot to the next, namely, is the transmission cycle length of the cognitive user's perception. According to the state

transition diagram, the probability of a busy channel in the channel can be obtained as follows:

$$\begin{aligned} P_{01}^i(\Delta t) &= 1 - P_{00}^i(\Delta t) \\ P_{11}^i(\Delta t) &= 1 - P_{10}^i(\Delta t) \end{aligned} \quad (12)$$

Then the idle probability of channel  $i$  in the next phase is shown below:

$$P_i = \begin{cases} P_{00}^i = \frac{\lambda_{OFF} + \eta_i e^{-(\lambda_{ON} + \lambda_{OFF})\Delta t}}{\lambda_{ON} + \lambda_{OFF}}, L_i = 0 \\ P_{10}^i = \frac{\lambda_{OFF} - \lambda_{OFF} e^{-(\lambda_{ON} + \lambda_{OFF})\Delta t}}{\lambda_{ON} + \lambda_{OFF}}, L_i = 1 \end{cases} \quad (13)$$

Where  $L_i$  refers to the state of channel  $i$  in last stage

The mathematical estimation result of the free probability can be simplified as follows according to the limit calculation rule in Advanced Mathematics.  $\lim_{x \rightarrow \infty} (1 + \frac{1}{x})^x = e, \lim_{x \rightarrow 0} e^{-x} = 1 - x$

Due to the sum of the rate parameters of off state duration and ON state duration of authorized users is very small, which is reaching to zero, the product of the transmission cycle and this sum will become almost infinitesimal [9]. To address this, this paper attempts to use the limit algorithm of composite function to simplify the equation (13).

$$\begin{aligned} P_{00}^i &= 1 - \eta_i + \eta_i \cdot e^{-(\lambda_{ON} + \lambda_{OFF})\Delta t} \approx 1 - \eta_i + \eta_i \cdot [1 - (\lambda_{ON} + \lambda_{OFF})\Delta t] \\ &= 1 - \frac{\lambda_{ON}}{\lambda_{ON} + \lambda_{OFF}} \cdot (\lambda_{ON} + \lambda_{OFF})\Delta t \\ &= 1 - \lambda_{ON}\Delta t \end{aligned} \quad (14)$$

$$\begin{aligned} P_{10}^i &= 1 - \eta_i - (1 - \eta_i)e^{-(\lambda_{ON} + \lambda_{OFF})\Delta t} \\ &= (1 - \eta_i) \cdot [1 - e^{-(\lambda_{ON} + \lambda_{OFF})\Delta t}] \\ &\approx (1 - \eta_i) \cdot (\lambda_{ON} + \lambda_{OFF})\Delta t \\ &= \lambda_{OFF}\Delta t \end{aligned} \quad (15)$$

### 3.2.3. Prediction Method of Spectrum Available Time:

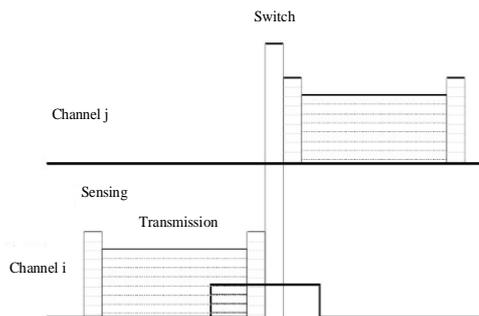


Figure 9. Lag Spectrum Switching

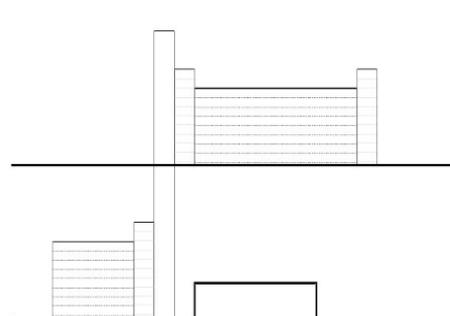
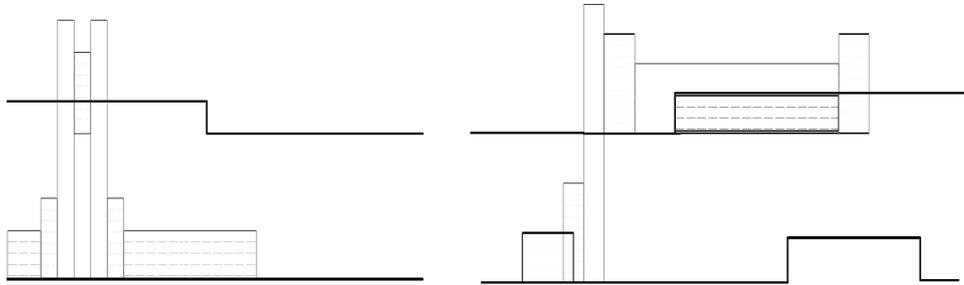


Figure 10. Advanced Spectrum Switching

Compared to the instant perception of the lag spectrum switch, advanced spectrum switching can greatly reduce the interference to the authorized users, as shown in Figure 10 and Figure 9. Spectrum handoff depends on the estimation of the authorized user behavior patterns. Either the random behavior of authorized user or the wrong results of perception or the wrong mathematical model can lead to the situation in Figure 11, namely, switching directly to a channel in busy. Even more, if only take idle probability

as the criterion of switching time, may cause such situation in Figure 12, that is, switching to a channel which has less slack time than the current channel. Both two cases shown in Figure 11 and Figure 12 are not wise spectrum handover. So calculation formula of free probability can be used to estimate the spectrum use time in the future to reduce the occurrence of unwise spectrum handover.



**Figure 11. Unwise Spectrum Switching I      Figure 12. Unwise Spectrum Switching II**

In the process of switching, the stability of the available resources, that is, the duration of the resource is an important factor which influence the switching times. In order to minimize the unwise spectrum handover and increase the wise spectrum handover, that is to say, switching to a residual idle longer channel, the remaining free of different channels are need to be calculated according to the formula (13) and the related knowledge of probability theory.

$$T_i = \frac{P_i}{\lambda_{OFF}} = \begin{cases} P_{10} \cdot \frac{1}{\lambda_{OFF}} \\ P_{00} \cdot \left( \frac{1}{\lambda_{OFF}} - (n+1)\Delta t \right) \end{cases} \quad (16)$$

In the expression above,  $n=0, 1, 2, \dots$ ,  $P_i$  indicates the idle probability of channel  $i$  in the next communication time slot, and  $\lambda_{OFF}$  expresses the rate parameter for OFF state continuous time negative exponential distribution of authorized users in the channel  $i$ . As shown in the formula (16), the calculation formula needs to be classified and discussed. The slack time calculation formula depends on the channel state in the communication time slot, if the state changes from 1 to 0, slack time length equal to idle probability multiplied by the rate parameters; if the state transfers from 0 to 0,  $t$  the channel has been idle for a period of time, slack time length is equal to the rate parameter minus the free time, then multiplied by idle probability [10].

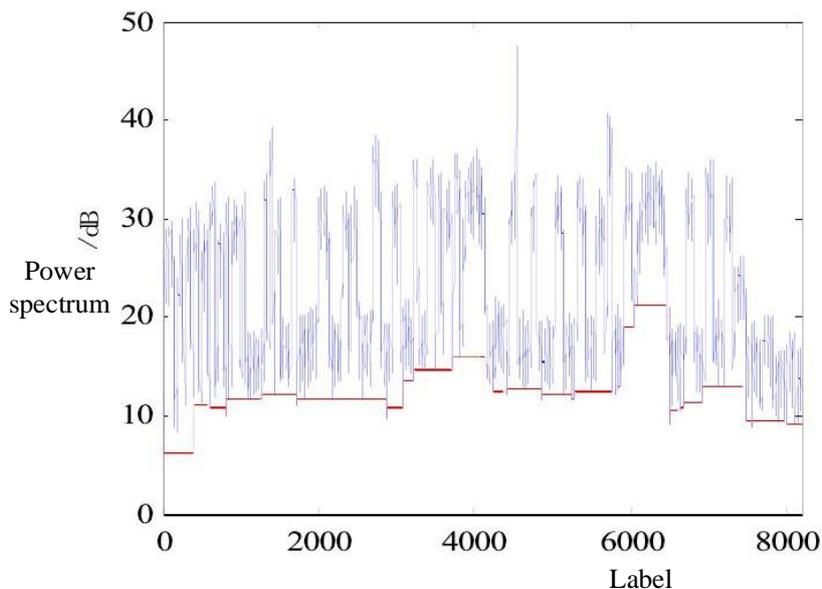
#### 4. Test Results

We have tested the function of cognitive radio dynamic spectrum access test platform, and mainly including the wideband spectrum sensing function and fast spectrum switching function of cognitive radio. In the indoor wireless communication environment, we directly use antenna to transmit radio signals for testing.

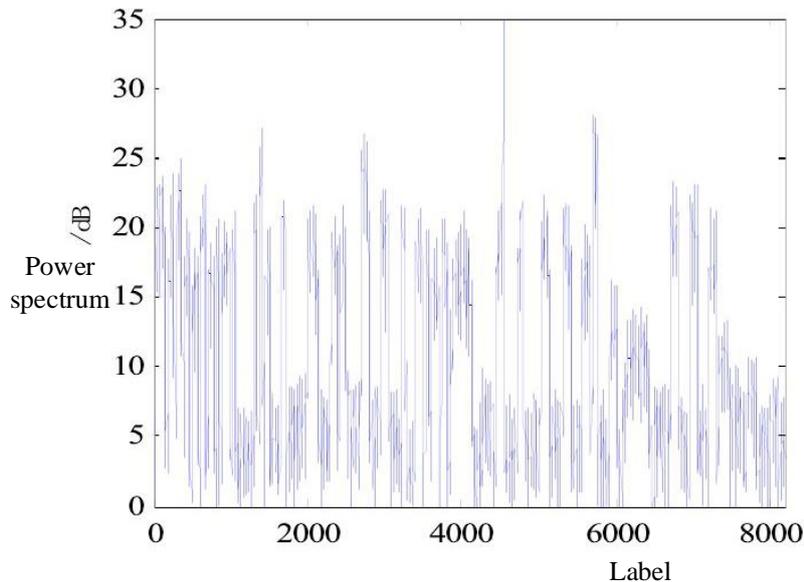
By repeated experiments on working frequency band from 30MHz-512MH, we found that cognitive radio can automatically find the idle channel to establish a link without knowing each other's frequency information. Its link establishment can adapt to the dynamic changes of the spectrum environment and both sides of the inconsistent environment. When the current communication channel is reoccupied by the primary user, the communication channel can automatically and quickly switch to other idle channels to continue communication.

#### 4.1. Spectrum Sensing Function Test

Firstly, we carried out the spectrum sensing function test. Figure 13, shows the results of noise base estimation, which was a Matlab drawing with its data derived from the DSP. The horizontal coordinates in the figure are not marked with specific frequency value, but the sample index after power spectrum estimation. As Figure 13 (a), shows, the signals are very intensive, the bottom lines in Figure 13 (a) expresses the estimating noise floor, which adaptively tracking the non-smooth characteristic of noise. Figure13 (b), shows the signal power spectrum after the remove of the estimated substrate noise spectrum. It can be seen from the figure, substrate noise has become flat in the signal power spectrum. It also illustrates the effectiveness of the adaptive noise floor estimation method.



(a) Original Power Spectrum and the Estimated Noise Base



(b) Power Spectrum after Noise Removal

**Figure 13. Results of Adaptive Noise Base Estimation**

Figure 14, shows the results of FCME detection of power spectrum after removing the influence of uneven noise. The high value of the rectangle indicates that the frequency is occupied by the primary user, and the low value is expressed as the spectrum hole. It can be seen from the figure that the method can find the main user signals accurately.

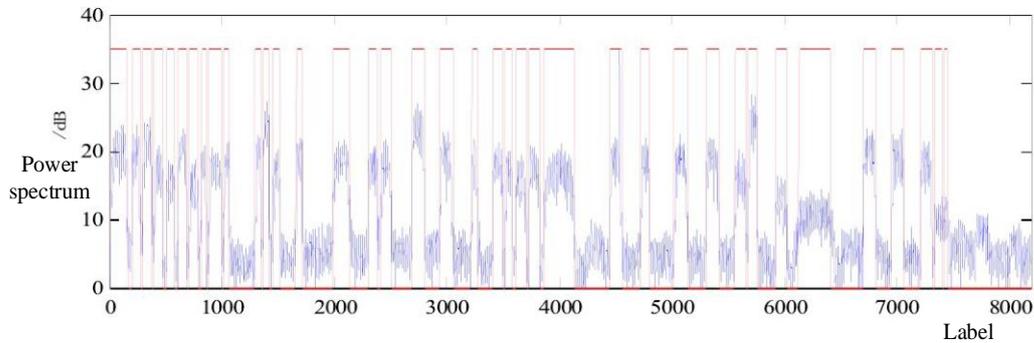
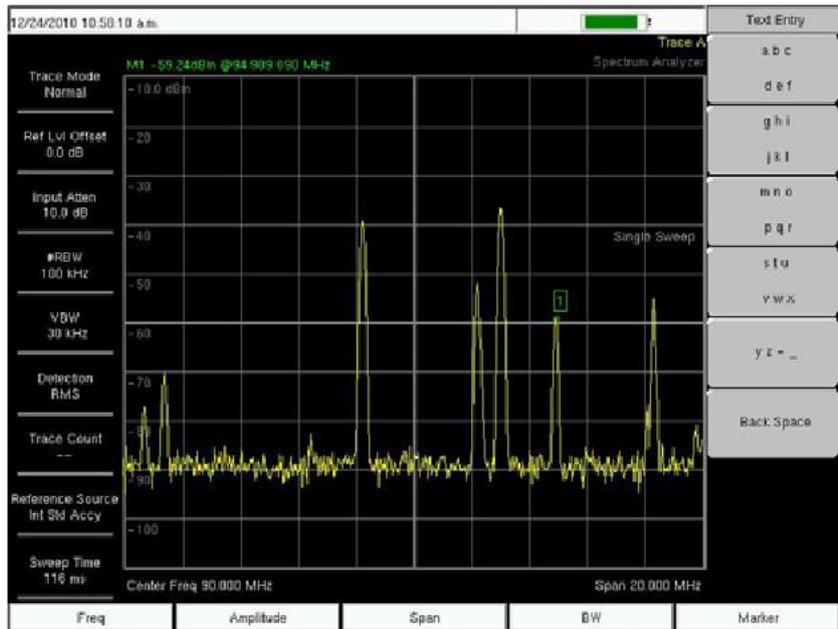


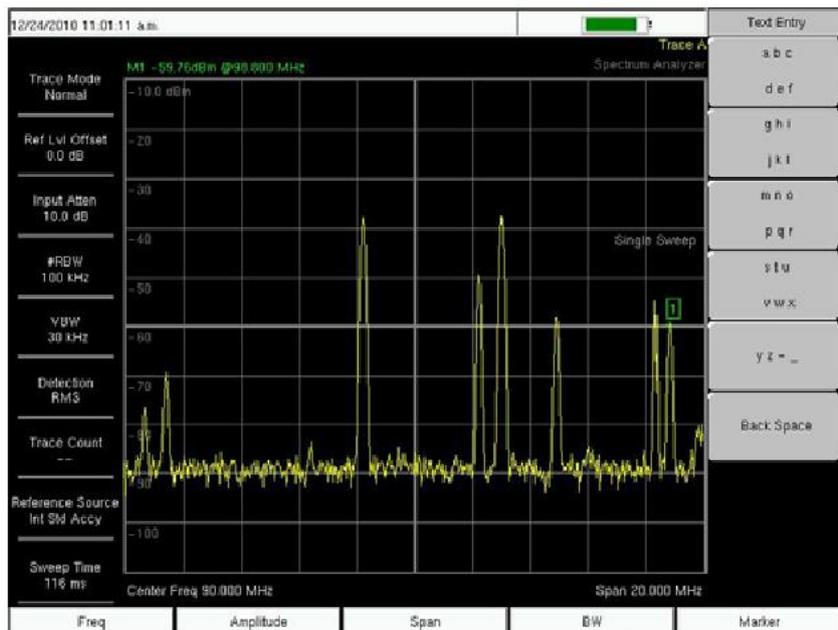
Figure 14. Spectrum Sensing Results

#### 4.2. Spectrum Switching Function Test

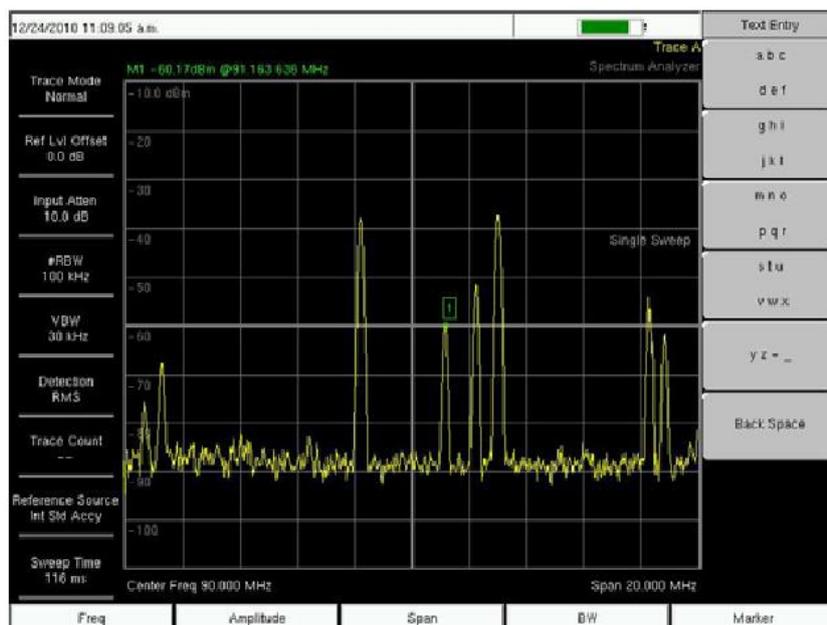
We have carried out a lot of experiments on the spectrum switching function of cognitive radio, including the on-line detection function to the main users, and the fast spectrum switching function when the main users appear. Figure 15, shows a test result. In Figure 15 (a), when cognitive radio was communication on channel 94.900MHz, we transmit signals by the signal source on channel 94.900MHz, then we found that cognitive radio immediately switch to channel 98.825MHz to continue communication. As seen in Figure 15 (b), we again sent signals on channel 98.825MHz, and finally found that cognitive radio immediately switch to the channel 91.150MHz to communication, with avoiding the primary user signals on channel 98.825MHz. As shown in Figure 15 (c), below, spectrum switches fast and smoothly, at the same time ,it can maintain communication uninterrupted.



(a) Cognitive Radio Communication on 94.900MHz



(b) After the Launch of the Interference of Channel 94.900MHz, Channel 98.825MHz Keep Communication



(c) After the Launch of the Interference of Channel 98.825MHz , Channel 91.150MHz Keep Communication

**Figure 15. Cognitive Radio Spectrum Switching Function Test**

## 5. Conclusion

This paper, in terms of the wideband spectrum sensing, puts forward a wideband spectrum sensing method based on GT. The experimental results show that when in low spectrum occupancy rate, the required number of dualistic detection of this method is much less than that of the traditional method, so the calculation of the wideband spectrum sensing complexity was reduced and the success of reconstruction can be accurately judged. This greatly reduces the interference probability for primary user of channel reconstruction when in dense spectrum. Concerning spectrum handoff, this paper uses pre

spectrum handoff scheme based on the spectrum prediction to achieve the method of available time prediction, and finally points out that applying the slack time method is better than the direct comparison of channel idle probability. of an The test results indicated that the spectrum handoff method proposed in this paper, to a certain extent, can improve the spectrum utilization ,shorten communication time by efficient switching and reduce the number of cognitive user's service is interrupted without interfering with the authorized users.

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