AN EFFICIENT SPECTRUM DECISION MAKING FRAMEWORK FOR COGNITIVE RADIO NETWORKS

Bhagyashree Anil Dere[1], Prof. Sheetal Bhujade[2]

[1]*P.G. Student, Department of E &TC Engineering, Saraswati College of Engineering, (India)*

[2]*Asst. Professor, Saraswati College of Engineering, Navi Mumbai, Maharashtra, (India)*

ABSTRACT

This review paper is based on the spectrum decision framework for cognitive radio networks. Cognitive radio networks have been proposed as a solution to both spectrum inefficiency and spectrum scarcity problems. However, they face to a unique challenge based on the fluctuating nature of heterogeneous spectrum bands as well as the diverse service requirements of various applications. In this paper, a spectrum decision framework is proposed to determine a set of spectrum bands by considering the application requirements as well as the dynamic nature of spectrum bands. To this end, first, each spectrum is characterized by jointly considering primary user activity and spectrum sensing operations. Based on this, a minimum variance based spectrum decision is proposed for real-time applications, which minimizes the capacity variance of the decided spectrum bands subject to the capacity constraints. For best-effort applications, a maximum capacity-based spectrum decision is proposed where spectrum bands are decided to maximize the total network capacity.

I. INTRODUCTION

Today's wireless networks are characterized as a static spectrum assignment policy. Recently, because of the increase in spectrum demand, this policy is faced with spectrum scarcity at particular spectrum bands. On the contrary, a large portion of the assigned spectrum is still used sporadically leading to underutilization of the significant amount of spectrum [9]. Hence, dynamic spectrum access techniques have recently been proposed to solve these spectrum inefficiency problems. The key enabling technology for dynamic spectrum access techniques is the cognitive radio technology, which provides the capability to share the wireless channel with licensed users (or primary users) in an opportunistic manner [1]. Cognitive radio (CR) networks are envisioned to provide high bandwidth to mobile users via heterogeneous wireless architectures and dynamic spectrum access techniques. CR networks, however, impose unique challenges because of the high fluctuation in the available spectrum as well as the diverse quality-of-service (QoS) requirements of various applications. To address these challenges, first, CR networks are required to determine which portions of the spectrum are available, called spectrum sensing [2], [10]. Furthermore, how to coordinate multiple CR users to share the spectrum band, called spectrum sharing, is another important issue in CR networks [7], [16]. Although all these efforts enable CR users to exploit spectrum opportunities effectively, the heterogeneous spectrum environment introduces a new critical issue in CR networks. Generally, CR networks have multiple available spectrum bands over a wide frequency range that show different channel characteristics, and need to support applications with diverse service requirements. Therefore, once available spectrum bands are identified through spectrum sensing, CR networks need to select the proper spectrum bands according to the application requirements. This process is referred to as spectrum decision, which constitutes an important but yet unexplored topic in CR networks. . To decide on spectrum bands properly, CR networks need to consider all available spectrum bands show different characteristics in the CR network. To select the proper spectrum, the CR network needs to characterize available spectrum bands by considering current radio conditions as well as the primary user (PU) activity. The CR network needs to provide a dynamic decision framework to consider all possible events that prevent reliable communications by closely interacting with other CR functionalities such as spectrum sensing and spectrum sharing. According to the PU activities, total capacity in CR networks varies over time, which makes it more difficult to decide on spectrum bands while maintaining the service quality of other CR users. Thus, the CR network should perform spectrum decision adaptively.

II. LITERATURE REVIEW

Most of the research on spectrum sharing in CR networks has mainly focused on how to efficiently allocate either spectrum or power among CR users subject to interference constraints. For spectrum allocation, a global optimization scheme is developed based on graph theory [17]. However, whenever the network topology changes according to the node mobility, the network needs to completely recomputed spectrum assignment leading to a higher computational and communication overhead. To solve this problem, a distributed spectrum allocation based on local bargaining is proposed in [4], where CR users negotiate spectrum assignment within local self-organized groups. For their source-constrained networks such as sensor and ad hoc networks, a rule-based spectrum management is proposed, where CR users access the spectrum independently according to both local observation and predetermined rules [5]. In [20], a dynamic channel selection scheme is developed for delay-sensitive applications based on a priority queuing analysis and a decentralized learning algorithm. Power allocation among CR users competing the same spectrum is another important issue in spectrum sharing. In [12], an optimal power allocation scheme is proposed to achieve ergodic and outage capacity of the fading channel under different types of power constraints and fading models. In [22], joint beam-forming and power allocation techniques are presented to maximize the user capacity while ensuring the QoS of primary users. Game theory provides an efficient distributed spectrum sharing scheme by describing the conflict and cooperation among CR users, and hence allowing each user to rationally decide on its be station. Thus, it has been widely exploited for both channel allocation [16] and for power allocation [7].

III. IMPLEMENTATION CHALLENGE IN SPECTRUM DECISION

All of the previous research explained above has mainly addressed spectrum sharing issues where all operations are performed within the same spectrum band or across contiguous channels. Furthermore, to adapt the fast time varying channels, they are generally designed as a short term operation, such as a packet-based or a time-slot based scheduling. However, CR networks necessitate an additional resource allocation capability when primary users are detected or CR users newly begin their sessions, which are relatively long-term events. Thus, this capability should consider longer-term channel characteristics, compared to spectrum sharing. In addition, since available spectrum bands are distributed over a wide frequency range, this function needs to be implemented as an inter- spectrum operation. However, this operation inevitably introduces an additional switching delay leading to service quality degradation. Thus, it is not desirable to extend existing spectrum sharing solutions designed to adapt to the fast time-varying channel to the long-term inter-spectrum operation. This unique challenge in CR networks has not been addressed in previous research.

IV. PROPOSED SYSTEM MODEL

A novel capacity model is developed to describe unique characteristics in CR networks by considering PU activity as well as sensing capability. Accordingly, two different decision schemes are introduced. To satisfy the delay constraints in real-time applications, we propose a minimum variance-based spectrum decision (MVSD) scheme that selects spectrum bands to minimize capacity variation. For best-effort applications, we propose a maximum capacity-based spectrum decision (MCSD) scheme to maximize the total network capacity. Both decision schemes are controlled by a proposed resource management based on the current network condition. System Model in this paper, we consider an infrastructure-based CR network that has a centralized network entity, such as a base-station. The base-station exerts control over all CR users within its transmission range. CR users perform the observations and analysis on radio environments and feed them to the central base-station, which decides on spectrum availability and spectrum allocation. Each CR user has multiple software-defined radio (SDR) transceivers to exploit multiple spectrum bands over a wide frequency range by reconfiguring the operating frequency through software operations. Here, we assume frequency division duplex (FDD) systems where uplink and downlink channels are separated. Thus, the proposed decision scheme can be applied to each link independently. When primary users appear in the spectrum band, CR users need to move to a new available band, resulting in a temporary communication break. To solve this problem, we assume that multiple noncontiguous spectrum bands can be simultaneously used for the transmission in the CR network. This method can create a signal that is not only capable of high data throughput, but is also immune to the PU activity. Even if a primary user appears in one of the current spectrum bands, the rest of them will maintain current transmissions [1].The control channel plays an important role in exchanging information regarding sensing and resource allocation. Several methods are presented in [3], one of which is assumed to be used as the common control channel in our proposed method.

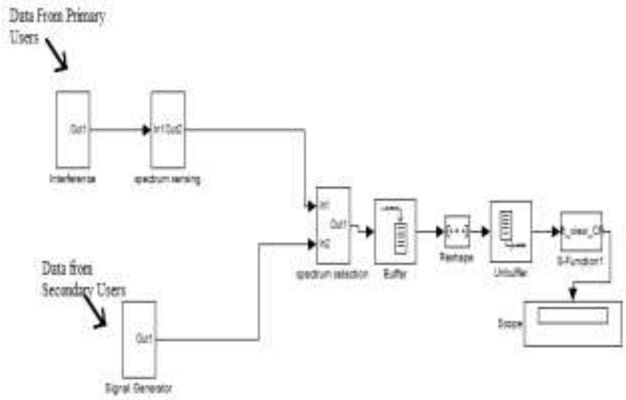

Fig 1 The Proposed Spectrum Decision Framework Model

V. DECISION FRAMEWORK OVERVIEW

The proposed spectrum decision framework model shown in Figure 1. consist of resource manager determines if the CR network accepts a new incoming CR user or not. If a new CR user is allowed to transmit, it is assigned to the proper spectrum bands through spectrum decision. Since there may be multiple CR users competing the same spectrum, spectrum sharing coordinates those multiple accesses to prevent collisions, and accordingly to achieve the maximum capacity. In the event detection, current spectrum bands and users connections are monitored to detect decision events. The event detection consists of two main tasks: spectrum sensing and quality monitoring. When events are detected, the CR network reconfigures its resource allocation to maintain the service quality. In case of short-term channel variations such as fast fading, the CR network reallocates resources within the spectrum band through spectrum sharing. If a primary user is detected or the current spectrum band cannot provide the predetermined service quality any longer over a long-term period, the CR network switches the spectrum through the resource manager and the spectrum decision.

VI. PRIMARY USERS DETECTION IN A SPECTRUM

The main system for the detection of multiple primary users is shown above in fig. 2(a). in this system five different primary users are detected.

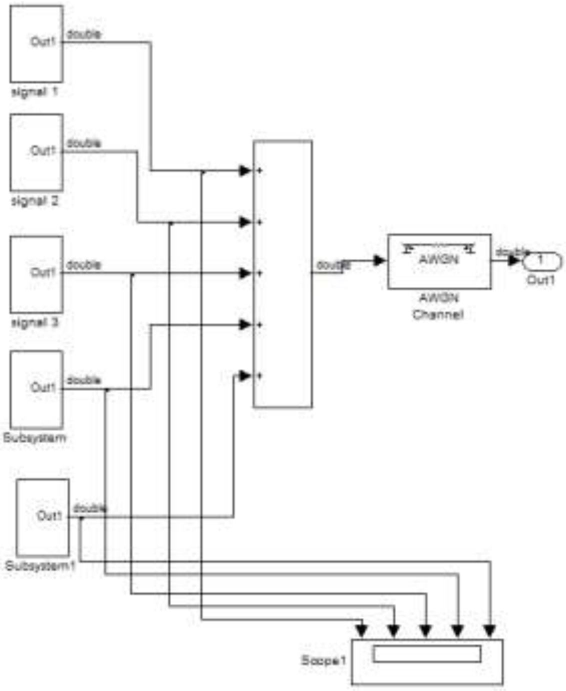

Figure 2(a) Primary Users Detected in a Spectrum

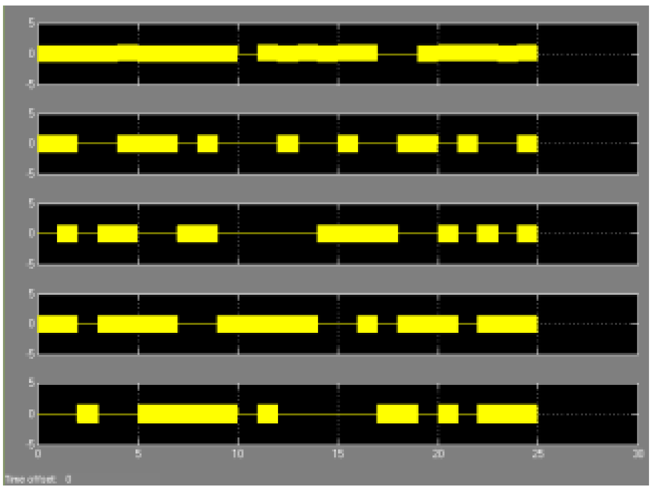

Fig 2 (b) Random Signals from Primary Users

Each user that is being detected generates random signals which are shown in the fig 2(b), further these five random signals are combined together and given to the workspace for comparing it with the Secondary Users or unlicensed users signal. Since these five combined signals are time-dependent signals they are further fed to the Fast Fourier transformation block in order to convert the time domain signals into frequency domain signals.

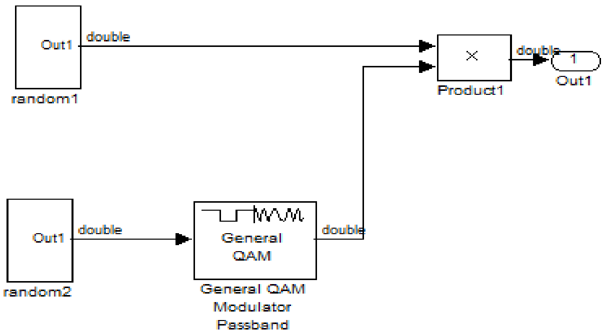

Fig 2(c) The Sub-System of Each Primary User

Each main system is divided into sub systems according to the number of users present in it as shown in fig 2(c). Random 1 and random 2 blocks generates random binary numbers. These digital signals are then combined with analog signal and their obtained product is obtained. Further the QAM modulator pass band block modulates the signal using double side-band amplitude modulation. The modulated signal is given to the main system as a Primary user signal.

VII. SPECTRUM SENSING MODEL

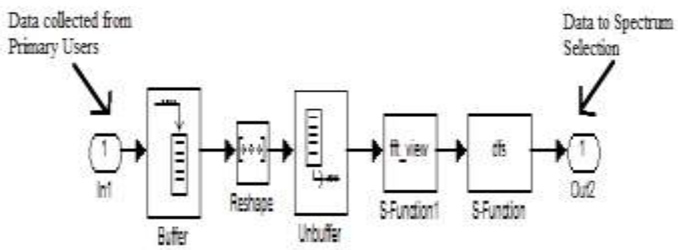

Fig 3(a) Spectrum Sensing Model

Data collected from multiple Primary Users is given to the spectrum sensing model as shown in fig.3 which consists of various blocks with different functions. The Buffer block redistributes the input samples to a new frame size. It collects the primary users' signals and sends the signals to the reshape block. The Reshape block changes the dimensionality of the input signal to a 2-D signal. The unbuffer block adjusts the output rate so that the sample period is the same at both the input and output. Further the sensed signals are fed to the frequency selection block.

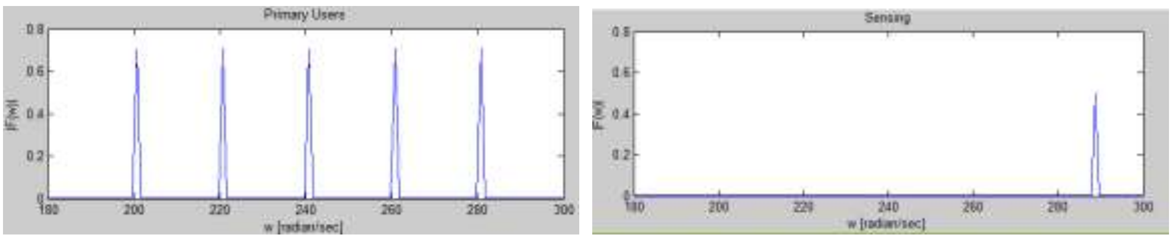

Fig 3(b) Response Generated by Sensing Model

VIII. SECONDARY USERS DETECTION IN A SPECTRUM

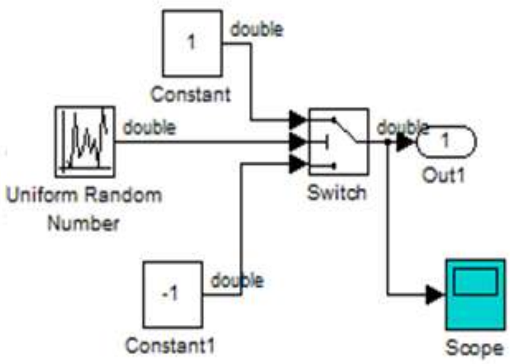

Fig 4(a) Secondary Users Detection in a Spectrum

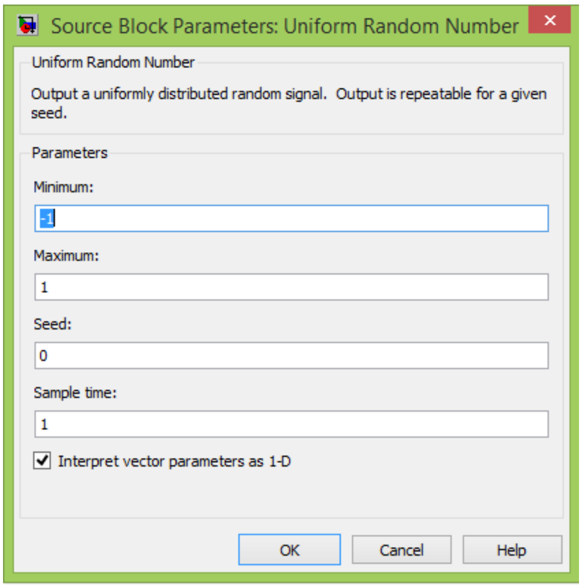

Fig 4(b) Parameters for Uniform Random Number Generator

Once the primary users are detected in spectrum, a random signal generator block generates random signals from the range -1 to 1. Seed is equal to 0 which indicates that the sequence is non-repeatable.

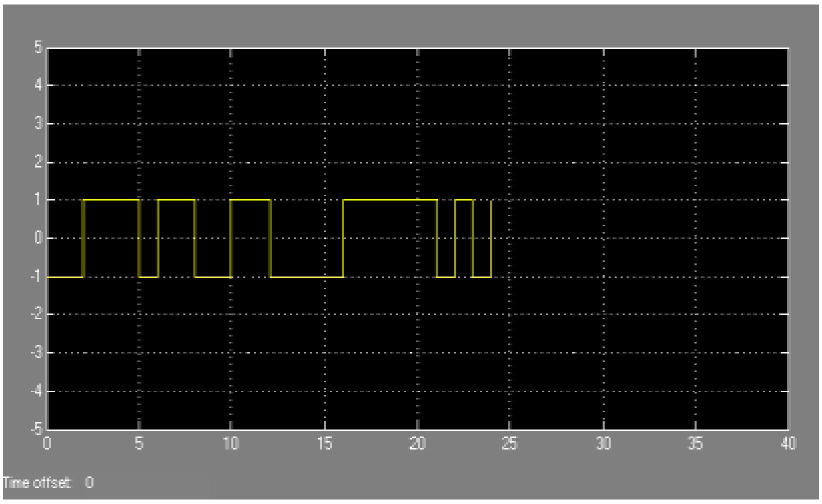

Fig 4(c) Random Signals from Secondary Users

IX. RESULTS AND DISCUSSION

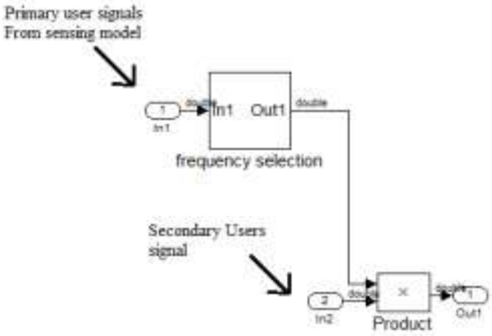

Fig 5(a) Frequency Selection Block

As shown in the above figure5(a) the Secondary Users signal and the Primary Users signals which are sensed in a sensing model are fed to the frequency selection block and further the product of Primary and Secondary Users is taken and Spectrum allocation is done as per the presence of users in a spectrum. The output of allocated spectrum is shown in the fig 5(b).

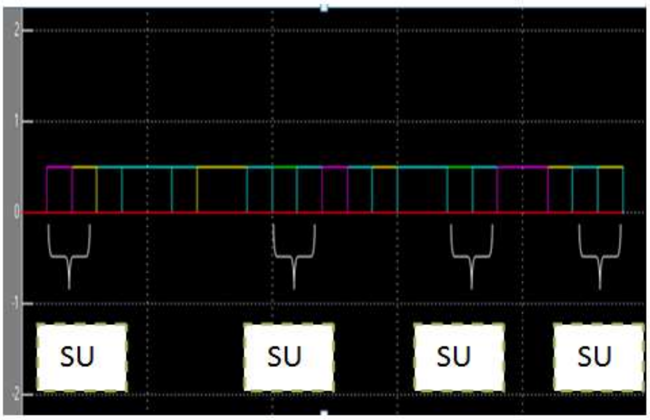

Fig 5(b) Spectrum Allocation to Secondary and Primary Users

X. CONCLUSION

In this review paper, we introduced a framework for spectrum decision to determine a set of spectrum bands by considering the channel dynamics in the CR network as well as application requirements. To this end, first, a novel spectrum capacity model is proposed that considers unique features in CR networks. Earlier cognitive model worked only for two Primary Users (PU) whereas this cognitive model works for five different Primary Users (PU).

Moreover, a dynamic resource management scheme is introduced to enable the CR network to coordinate spectrum decision adaptively dependent on the time-varying spectrum resources. Further the cognitive model for more than five licensed user is planned to be developed along with multiple unlicensed users or secondary used present in the same bandwidth.

XI. ACKNOWLEDGEMENTS

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REFERENCES

[1] I.F. Akyildiz, W.-Y. Lee, M.C. Vuran, and S. Mohanty, "A Survey on Spectrum Management in Cognitive Radio Networks," IEEE Comm. Magazine, vol. 46, no. 4, pp. 40-48, Apr. 2008.

[2] D. Cabric, S.M. Mishra, and R.W. Brodersen, "Implementation Issues in Spectrum Sensing for Cognitive Radios," Proc. IEEE Asilomar Conf. Signals, Systems and Computers, pp. 772-776, Nov. 2004.

[3] D. Cabric, S.M. Mishra, D. Willkomm, R. Brodersen, and A. Wolisz, "A Cognitive Radio Approach for Usage of Virtual Unlicensed Spectrum," Proc. 14th IST Mobile and Wireless Comm. Summit, June 2005.

[4] L. Cao and H. Zheng, "Distributed Spectrum Allocation via Local Bargaining," Proc. IEEE Sensor and Ad Hoc Comm. and Networks (SECON), pp. 475-486, Sept. 2005.

[5] L. Cao and H. Zheng, "Distributed Rule-Regulated Spectrum Sharing," IEEE J. Selected Areas in Comm., vol. 26, no. 1, pp. 130- 145, Jan. 2008.

[6] C. Chou, S. Shankar, H. Kim, and K.G. Shin, "What and How Much to Gain by Spectrum Agility?" IEEE J. Selected Areas in Comm., vol. 25, no. 3, pp. 576-588, Apr. 2007.

[7] R. Etkin, A. Parekh, and D. Tse, "Spectrum Sharing for Unlicensed Bands," IEEE J. Selected Areas in Comm., vol. 25, no. 3, pp. 517-528, Apr. 2007.

[8] J.R. Evans and E. Minieka, Optimization Algorithms for Networks and Graphs, second ed. CRC Press, 1992.

[9] FCC, ET Docket No 02-135, Spectrum Policy Task Force Report, Nov. 2002.

[10] M. Gandetto and C. Regazzoni, "Spectrum Sensing: A Distributed Approach for Cognitive Terminals," IEEE J. Selected Areas in Comm., vol. 25, no. 3, pp. 546-557, Apr. 2007.

[11] IEEE P802.22/D0.3.8.1, IEEE 802.22 WG, Draft Standard for Wireless Regional Area Networks Part 22: Cognitive Wireless RAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications: Policies and Procedures for Operation in the TV Bands, IEEE, Sept. 2007.

[12] X. Kang, Y. Liang, A. Nallanathan, H. Garg, and R. Zhiang, "Optimal Power Allocation for Fading Channels in CR Networks: Ergodic Capacity and Outage Capacity," IEEE Trans. Wireless Comm., vol. 8, no. 2, pp. 940-950, Feb. 2009.

[13] W.-Y. Lee and I.F. Akyildiz, "Optimal Spectrum Sensing Framework for Cognitive Radio Networks," IEEE Trans. Wireless Comm., vol. 7, no. 10, pp. 3845-3857, Oct. 2008.

[14] W.-Y. Lee and I.F. Akyildiz, "Spectrum-Aware Mobility Management in Cognitive Radio Cellular Networks," to be published. [15] Y.C. Liang, Y. Zeng, E. Peh, and A.T. Hoang, "Sensing- Throughput Tradeoff for Cognitive Radio Networks," IEEE Trans. Wireless Comm., vol. 7, no. 4, pp. 1326-1337, Apr. 2008.

[16] N. Nie and C. Comaniciu, "Adaptive Channel Allocation Spectrum Etiquette for Cognitive Radio Networks," Proc.First IEEE Int'l Symp. New Frontiers in Dynamic Spectrum Access Networks (DySPAN '05), pp. 269-278, Nov. 2005.

[17] C. Peng, H. Zheng, and B.Y. Zhao, "Utilization and Fairness in Spectrum Assignment for Opportunistic Spectrum Access," ACM Mobile Networks and Applications, vol. 11, no. 4, pp. 555-576, Aug. 2006.

[18] M.R. Chari, F. Ling, A. Mantravadi, R. Krishnamoorthi, R. Vijayan, G.K. Walker, and R. Chandhok, "FLO Physical Layer: An Overview," IEEE Trans. Broadcasting, vol. 53, no. 1, pp. 145-159, Mar. 2007.

[19] T. Rappaport, Wireless Communications: Principles and Practice, second ed. Prentice Hall, 2001.

[20] H. Shiang and M. Schaar, "Queuing-Based Dynamic Channel Selection for Heterogeneous Multimedia Applications over Cognitive Radio Networks," IEEE Trans. Multimedia, vol. 5, no. 10, pp. 896-909, Aug. 2008.

[21] K. Sriram and W. Whitt, "Characterizing Superposition Arrival Processes in Packet Multiplexers for Voice and Data," IEEE J. Selected Areas in Comm., vol. 4, no. 6, pp. 833-846, Sept. 1986.

[22] L. Zhang, Y. Liang, and Y. Xin, "Joint Beamforming and Power Allocation for Multiple Access Channels in Cognitive Radio Networks," IEEE J. Selected Areas in Comm., vol. 26, no. 1, pp. 38-51, Jan. 2008.