

Novel Channel Allocation Model for Multimedia Streaming Over Centralized Cognitive Radio Networks

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ABSTRACT :Multimedia applications have being widely supported by cognitive radio networks in which high Bandwidth can be provided by fully utilizing radio spectrum. However, the research communities lack a theoretical modeling and analysis for multimedia system performance over cognitive radio networks. A novel Markov-Chain based model of centralized cognitive radio network (CCRN) consisting of APs and user equipments (UEs) equipped with several antennas (one antenna for channel sensing, the others for data communication) is proposed. In the proposed model, AP will scan the idle primary Channels (PCs) that are not used by primary users (PUs), and then transmit data through selected idle channels. Each selected channel in CCRN will be divided into many sub-time slots and some of them are used as the signaling control and the other slots are used only for data transmissions. In addition, three types of communications are considered and an appropriate number of time slots are pre-assigned to ensure QoS of multiple types of multimedia traffic. A multi-dimension Markov chain to model time slot allocation and proposed a general channel allocation model for multimedia traffic over CCRN.

I.INTRODUCTION

Multimedia applications have being widely supported by cognitive radio networks in which high bandwidth can be provided by fully utilizing radio spectrum. In existing priority based system method there is lack of infrastructure in a network. So, the transmission of packets in networks is difficult, due to that the data could be lost and it is insecure for multimedia transmission. Channel allocation for defining a path is also difficult.

The novel Markov-Chain based model of centralized cognitive radio network (CCRN) for an infrastructure based network has been introduced for channel allocation scheme. There are two types of allocation for multimedia transmission namely Channel allocation using Markov model and time slot allocation using multidimensional Markov model. Infrastructure based network for both wired and wireless communication has several channels which are divided into sub time slots and then transmitted. This is done by uplink and downlink process. However, in the CCRN, each communication node is usually equipped with multiple antennas and these antennas are dynamically set to sending/receiving/idle status. The number of working antennas may be dynamically changed according to the arrival of PUs.

The channel allocation and time slot is done by TDMA scheduling for the primary and secondary users in the CCRN region. TDMA scheduling for time slot is a pre-assigned, and the protocol used for transmission of packets from one region to another is aodv protocol for the path assignment. And the network performances for the primary and secondary users are obtained by NS2 simulator.

II. COGNITIVE RADIO NETWORKS

Cognitive radio is a radio that can change its transmission parameters based on what it learns from the environment in which it operates. It is a technology that allows unlicensed users to operate in underutilized licensed frequency bands in an intelligent way without intruding the privileges of licensed users. Cognitive radio is a wireless communication system which is aware of the environment and its changes and can adapt its transmission parameters accordingly.

Why Cognitive Radio?

Current wireless networks are regulated by fixed spectrum assignment policy. According to Federal Communication Commission, temporal and geographical variations in the utilization of the assigned spectrum range from 15% to 85%.

Fixed Spectrum Assignment policy \longrightarrow spectrum white spaces

Cognitive radio network is a new paradigm that provides the capability to share or use the spectrum in an opportunistic manner. If a frequency band is unused now, it is gone forever – so think in terms of detecting and utilizing spectral “holes”. This alteration of parameters is based on the active monitoring of several factors in the external and internal radio environment, such as radio frequency spectrum, user behaviour and network state.

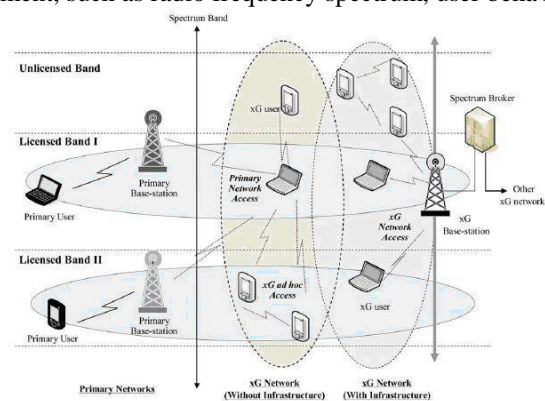


Fig.1.Cognitive Radio Network Architecture

III.CENTRALIZED NETWORK

Novel Markov-chain model based models of centralized cognitive radio network (CCRN) consist of APs and user equipments sensing, and other for data communication. In the proposed model channel allocation for an infrastructure is done by Markov chain model and time slot is done using multi-dimension Markov model for signaling and QoS support.

A. Necessity of Infrastructure Based Network

1. First, it is aware of its environment and its capabilities.
2. Second, it is able to independently alter its physical layer behavior based on its previous experience and its current environment.

3. Finally, it is capable of performing the complex adaptation strategies according to the cognitive cycle. With these capabilities, when spectrum environment changes around cognitive user, it is capable of sensing these changes and independently changing its physical layer settings such as transmission power, channel selection and etc to meet some constraints or QoS requirements of the users.

In the CCRN, each communication node is usually equipped with multiple antennas and these antennas are dynamically set to sending/receiving/idle status. The number of working antennas may be dynamically changed according to the arrival of PUs. Most of existing works ignore the practical and real configurations. To be best of our knowledge, there are no existing research works that model an infrastructure based cognitive radio networks for multimedia transmission. A theoretical analysis model for this network is strongly required to evaluate multimedia system performance in CCRN. In this paper, we studied an infrastructure based cognitive radio networks in which both access point (AP) and primary user base station (PBS) co-exist in the networks and the AP is acted as the center of slot allocation and data relay.

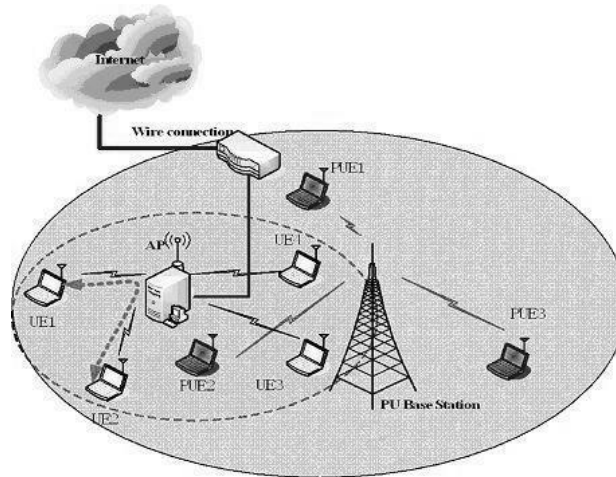


Fig.2 Infrastructure Based Cognitive Radio Network

Fig. 1 shows the proposed infrastructure which includes three types of communications: between UEs within CCRN, from UEs in CCRN to the nodes outside CCRN, and from nodes outside CCRN to the UEs in CCRN. As described in Fig. 1, the PBS manages all the PCs that can be freely used by the nodes of primary user equipment (PUE), while some idle PCs can be used by other second users in the CCRN. The CCRN consists of access points (AP) that connects user equipment (UEs). AP communicates with other nodes outside CCRN via either wire or wireless connections. All APs and UEs are equipped with multiple antennas.

Table.1 Symbols and Notations

Symbol	Notations
N_s	Number of time slots for each channel used by CCRN
N_h	Number of time slots for signalling per channel.
N_c	Time slot number for data transmission per channel: $N_c = N_s - N_h$
N_f	idle time slots per channel in CCRN, which are not used by any users.
N_a	Number of available slots per channel.
D	Number of multimedia traffic types
$d1, d2$	The minimum and maximum slots required for a call.
λ^p	The arrival rate of PUs
$\lambda_{a,b,c,k}^s$	The arrival rate of SU of type-(a,b,c,k)
u^p	The service rate of PUs.
u^s	The service rate of SU if one slot is used.

In the infrastructure based cognitive radio networks, free channels of a PU are scanned and reused by the CCRN. AP decides what channels could be re-used and maintains the resource allocation and data relay. For example, we can assume that TDMA based protocol is applied. Each frame last 10ms consisting of 40 OFDM signals, and each signal (signal slot) last 250 s. Each channel reused by AP will be divided into multiple time slots and be reallocated to SUs. Two types of frames will be also classified due to the needs of signaling and data exchange between the AP and UEs. The signaling from AP to UE includes the synchronizing, cognition information broadcast and allocation table broadcasting. The signaling from UE to AP includes upper layer application QoS requirements which will be sent by UE to AP via a fixed slot. In the paper, we focus on the time slots allocation and assume the QoS requirement information always can be sent to AP successfully. There is an interrupt from physical layer of UE every 10 ms. The major symbols we used in the paper are listed in Table1.

B. Basic Definitions and Assumptions

In the proposed infrastructure based Cognitive radio networks, we assume that there are N PCs (primary channels) that are used by the PUs (Primary Users). In many scenarios, PCs are used by PUs while $N_{sc} (= N - N_{pc})$ PCs Can be used by the SUs. The maximum number of channels the SUs can use is M . M is the number of antennas each UE is equipped. When $0 < N_{sc} < M$ is satisfied, only N_{sc} channels can be used. If $N_{sc} = 0$, then all the antennas should be turned off and the communication of the CCRN will be interrupted. Each channel will be divided into T sub channels and T_1 of them should be used as signaling such as time synchronization and time slot allocation. The other T_2 ($T_2 = T - T_1$) time slots are only used for data transmissions. If the number of channels the CCRN used is N_w , then N_w antennas are working and $(M - N_w)$ antennas should be turned off. If there are total D types of multimedia traffic in CCRN, the least number of time slots should be guaranteed for each traffic in order to assure the QoS. For example, some multimedia traffic require at least sub slots for transmissions, then the system should allocate $k (k \geq c_1)$ time slots. On the other hand, any type of traffic requires at most ch sub slots for data transmissions. For each node equipped with multi-antennas, number of k slots should be allocated to the user, and may be larger than ch . However, it must follow $ch \leq k < (ch+1) * N_w$. This is because the working antennas will be in receiving/sending status at a same time due to the limitation of hardware.

Time Slot Calculations

Multiple slot allocation patterns can apply for different communication modes. For the communication among users in the CCRN, the number of time slots for the uplink allocated to the sender is equal to the number of time slots for the downlink allocated to the receiver. Because the communication between a user within CCRN and a node outside of CCRN involves both wireless and wired connections, we should consider the Difference for the time slot allocation specifically. In addition, both AP and UE need to exchange signaling information for the uplink and downlink. The detail of multiple time slot definition is shown in Table2.

Table.2 Time Slot Calculations

Index	Types	from	to	source	destination
1	Uplink (control slot)	UE1	AP	UE1	AP
2	Downlink (control slot)	AP	UE1	AP	UE1
3	Uplink (Data slot)	UE1	AP	UE1	UE2
4	Downlink (Data slot)	AP	UE2	UE1	UE2
5	Uplink (Data slot)	UE1	AP	UE1	A node outside CR
6	Downlink (Data slot)	AP	UE1	A node outside CR	UE1

Call Type Classification

According to the different communication modes in Table 2, we can classify the calls into three types as shown in Table 3. Among the call types described in Table 3, for a given type-(in,in,cl,ch,0), type-(in,out,cl,ch,0) or type-(out,in,cl,ch,0) call, the call will be allocated $k (k \geq cl)$ slots for transmission if it is accepted by the system. Then the call on communication is denoted as type-(in,in,cl,ch,k), type-(in,out,cl,ch,k) or type-(out,in,cl,ch,k). If some channels CCRN used are reoccupied by the arriving PUs, the AP will try to re-allocate the slots to the ongoing users to avoid the call termination. In this scenario, some calls may be dropped due to the unavailability of time slots. If only a single directional link (uplink or downlink) slots allocation is considered and there are enough number of slots to be allocated, total slots on a single direction link will be allocated for the SU. Because the number of working antenna is , the allocated total slots are $\phi(c, N_w), \phi(c, N_w) \geq c$. The function can be defined as follows:

$$\phi(c, N_w) = c, \quad \text{if } \text{mod}(c, N_w) = 0$$

$$[c/N_w + 1]N_w \quad \text{if } \text{mod}(c, N_w) \neq 0$$

In (1), $\phi(c, N_w)$ represents the total time slots allocated to a SU. The time slots allocated to the SU per channel (or per antenna) is $\Omega(c, N_w)$, which is expressed in the following.

$$\Omega(c, N_w) = \phi(c, N_w) / N_w.$$

Table.3 Call Type Classification

Call Type	Notes
Type-(in,in,cl,ch,0), or Type-(1,cl,ch,0) call	This type represents the calls among UEs in the same CCRN and the call needs at least C_l and at most C_h slots for transmissions.
Type-(in,out,cl,ch,k), or Type-(2,cl,ch,k) call	This type represents a call between a UE and node outside CCRN. In this case AP should relay the message to the nodes outside the CCRN.
Type-(out,in,cl,ch,k) or Type-(3,cl,ch,k) Call	The source node is outside CRN and destination is UE, so AP should relay the message to the nodes outside CCRN through wire connection.

C. States Definitions and Basic Formulas

Given a fixed, the state of the SUs can be modeled as follows:

$$E_{N_w} = \left\{ \begin{matrix} j_1^1 1, \phi(1, N_w), \dots, j_2^1 cl, ch, \phi(cl, N_w), \dots, j_3^1 d1, d2, \phi(d1, N_w) + (d2 - d1)N_w, \\ j_2^1 1, \phi(1, N_w), \dots, j_3^1 cl, ch, \phi(cl, N_w), \dots, j_4^1 d1, d2, \phi(d1, N_w) + p(d2 - d1)N_w, \\ j_3^1 1, \phi(1, N_w), \dots, j_4^1 cl, ch, \phi(cl, N_w), \dots, j_5^1 d1, d2, \phi(d1, N_w) + (d2 - d1)N_w. \end{matrix} \right. \quad (2)$$

Where is the number of calls of type-(k,a,b,c) as described above. The elements in E are indexed by four integer a,b,c and k. We reordered the index of a,b,c and k, and only use integer to index the elements. The total number of elements for a fixed is N_w is $N_{state, N_w} = 3d_1(d_2 - d_1 + 1)$ and the number of total states is $N_{total} = \sum_{i=0}^{N_w} N_{state, i}$. For a certain N_w , the element indexed by (a,b,c,k) will be indexed by n_{index} , $1 \leq n_{index} \leq N_{state, N_w}$. After we map the four elements index {a,b,c,k} to n_{index} , E_{N_w} can be described in (3):

$$E_{N_w} = \left\{ \begin{matrix} (e_{1, 1, \phi(1, N_w), 1}, \dots, e_{cl, ch, \phi(cl, N_w) + (ch-cl)N_w, 1}, \dots \\ e_{1, 1, \phi(1, N_w), 2}, \dots, e_{cl, ch, \phi(cl, N_w) + (ch-cl)N_w, 2}, \dots \\ e_{1, 1, \phi(1, N_w), 3}, \dots, e_{cl, ch, \phi(cl, N_w) + (ch-cl)N_w, 3}, \dots \end{matrix} \right. \quad (3)$$

The state of includes a series of sub state blocks. Space E is represented as $\{i, E_1, E_2, \dots, E_{N_w} \dots E_w\}$ where i is the number of PUs. The total state space can be shown as $E^1, E^2, \dots, E^{N_{total}}$. All elements in E but not belonging to E_{N_w} are zero. we defined two functions. one function is to translate four elements index to one integer index as shown in the following:

$$N_{index} = \xi(a, b, c, k). \quad (4)$$

The other is to convert one integer index to four elements index:

$$(a, b, c, k) = N(n_{index}) = \xi^{-1}(n_{index}). \quad (5)$$

The sub index of these four elements can be expressed in (6):

$$\begin{aligned} a &= N_1(n_{index}), \quad b = N_2(n_{index}), \\ c &= N_3(n_{index}), \quad k = N_4(n_{index}), \end{aligned}$$

Therefore, the elements in the state E, can be noted as $e_k, e_{N(k)}$, or $e_{N_1(k), N_2(k), N_3(k), N_4(k)}$ separately, where $k > 1$. If $k=0$ then e_0 is i. The elements for state E^i can be noted as $e_k^i, e_{N(k)}^i$ or $e_{\xi N_1(k), N_2(k), N_3(k), N_4(k)}^i$. For the communication within CCRN, the time slots must be allocated to the sender and the receiver simultaneously so that the reduced number of available slots is the twice of that allocated to the sender. Therefore, and can be expressed in (7):

$$N_a = 2 \sum_{c=\Omega(a, N_w)}^{\Omega(b, N_w)} \sum_{b=1}^{d_2} \sum_{a=1}^{d_1} (c - \Omega(a, N_w)) e_{a,b,c,1} - \sum_{k=2}^3 \sum_{c=\Omega(a, N_w)}^{\Omega(b, N_w)} \sum_{b=1}^{d_2} \sum_{a=1}^{d_1} (c - \Omega(a, N_w)) e_{a,b,c,k} + N_f$$

IV.NETWORK PERFORMANCE METRICS

We evaluate the cognitive network performance using two metrics: throughput and packet delivery ratio.

Throughput in communication network, such as Ethernet or packet radio, throughput or network throughput is the average rate of successful message delivery over a communication channel. The throughput is usually measured in bits per second (bit/s or bps), and sometimes in data packets per second or data packets per time slot

$$T = \sum_{s \in \psi} \left(u^s \sum_{i=1}^{N_{stat}^s} (1 + 1|k=1|) c N_w^s e_i^s \right)$$

T represents the throughput that is defined as the average numbers of service completions for SUs per second. u^s - The service rate of SU if one slot is used. N_w^s - is the number of working antenna in secondary k - Number of slots allocated to users and e_i^s - is the transition rate used.

Packet delivery ratio is total number of packets sent is equal to the sum of the packets received and dropped in a network.

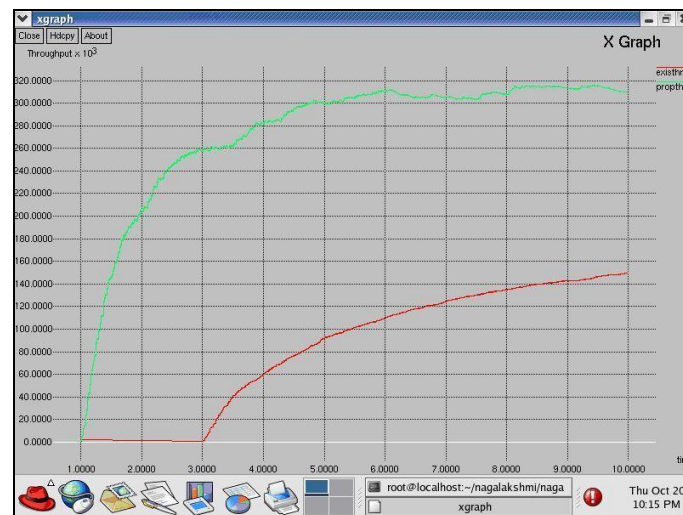


Fig.3. Throughput for SUs

Throughput analysis for the secondary users in CCRN increases with increase in time and also the decrease in arrival rate of PUs, so that efficiency in a network increases and more number of data can be transmitted. The x axis represents time in seconds and the y axis represents throughput in kbps. The efficiency of the throughput increases linearly and becomes constant at 5secs in proposed system with increase in time.

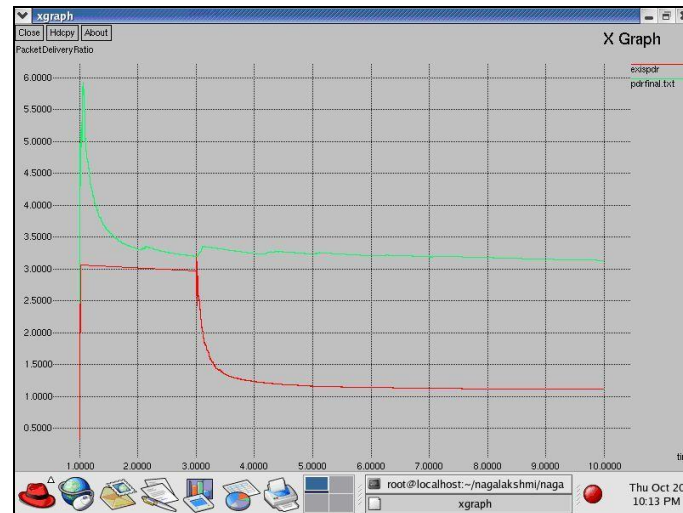


Fig.4 Packet Delivery Ratio

The Packet delivery ratio with time performance is shown as above, as the number of packets in a network decreases with increase in time and also the performance of the PDR is compared with the existing model delay. The x axis represents the time in seconds and y axis represents the packet delivery ratio in kbps. The performance analysis of proposed model is improved with time and becomes constant at 3.2secs.

V. CONCLUSION

In the CCRN, each communication node is equipped with multiple antennas and these antennas are dynamically set to sending/receiving/idle status. The number of working antennas is dynamically changed according to the arrival of PUs. They are in sending/receiving state at the same time due to the hardware limits. Three types of calls with different slot requirements are studied. Hence, a multi-dimensional Markov chain to model the channel allocation for multimedia streaming over CCRN is used.

The signaling and data transmission in CCRN region is improved and the pre-assigned time slot ensures the Qos. The multimedia transmission for wireless network is done by time scheduling algorithm (TDMA). Thus the performance of throughput and packet delivery ratio increases with time and the performance of multimedia traffic are evaluated.

VI.FUTURE ENHANCEMENT

No of nodes are increased in CCRN region. The multimedia transmission will be done for wired network. A simple BCC (blocking call cleared) queuing model will be used, when an arrival SU find that there are no available channels in the system. The overall performance evaluation for the wired network will be analyzed and the performance of both wireless and wired network will be compared.

REFERENCES

- [1] Ali A. and Yu R., "Cross-layer QoS provisioning for multimedia transmissions in cognitive radio networks," in *Proc. IEEE WCNC*, 2009.
- [2] 2.Du W., Jia W., Wang G., and Lu W., "Analysis of channel allocation scheme for wireless cellular networks," *Int. J. Ad Hoc Ubiquitous Comput.*, vol. 4, no. 3/4, pp. 201–209, 2009.
- [3] Gunawardena S and Zhuang W., "Voice capacity of cognitive radio networks," in *IEEE Int. Conf. Communications (ICC)*, May 23–27,2010, pp. 1–5.

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- [4] Hu D., Mao S., Hou Y.T., and Reed J.H., "Scalable video multicast in cognitive radio networks," IEEE J. Sel. Areas Commun., vol. 28, no. 3, pp. 334–344, Apr. 2010.
- [5] Hu D. and Mao S., "Streaming scalable videos over multi-hop cognitive radio networks," IEEE Trans. Wireless Commun., vol. 9, no. 11, pp. 3501–3511, Nov. 2010.
- [6] Jung P., Viessmann D., Spiegel C., Burnic A., Bai Z., Bruck G.H., Statnikov H., Waadt A., Wang S., Popon X., Velilla R.R., Saarnisaari, Alles M., Brack T., Kienle F., Berens F., Rotolo S., Scalise F.M., and When N., "Cognitive radio prototyping," in 3rd Int. Conf. Cognitive Radio Oriented Wireless Networks and Communications, CrownCom 2008, May 15–17, 2008, pp. 1–6.
- [7] Kushwaha H., Xing Y., Chandramouli Y., and H. Hefes, "Reliable multimedia transmission over cognitive radio networks using fountain codes," Proc. IEEE, vol. 96, no. 1, pp. 155–165, Jan. 2008.
- [8] Li X and Zekavat S.A., "Spectrum sharing across multiple service providers via cognitive radio nodes," IET Commun., vol. 4, no. 5, pp. 551–561, Mar. 2001.
- [9] Shiang H.P and van der Schaar M, "Queueing-based dynamic channel selection for heterogeneous multimedia applications over cognitive radio networks," IEEE Trans. Commun, vol. 10, no. 5, pp. 896–909, Aug. 2008.
- [10] Wang P., Niyato D., and Jiang H., "Voice service support over cognitive radio networks," in IEEE Int. Conf. Communications, Jun. 14–18, 2009, pp. 1–5.
- [11] Zhou L., Xiong N., Shu L., Vasilakos A., and Yeo S.S., "Contextaware multimedia service in heterogeneous networks," IEEE Intell.Syst., vol. 25, no. 2, pp. 40–47, Mar./Apr. 2010.
- [12] Zhou L. and Zhang Y., "Distributed media-service scheme for P2P based vehicular networks," IEEE Trans. Veh. Technol., vol. 60, no. 2, pp. 692–703, Feb. 2011.
- [13] Zhou L., Wang X., Tu W., Mutean G., and Geller B., "Distributed scheduling scheme for video streaming over multi-channel multi-radio multi-hop wireless networks," IEEE J. Sel. Areas Commun., vol. 28, no. 3, pp. 409–419, Apr. 2010.