SPECTRUM SCHEDULING: THE KEY FACTOR FOR MAXIMUM THROUGHPUT AND OPTIMAL RESOURCE UTILIZATION IN COGNITIVE RADIO NETWORK.

M. Tahir Mushtaq[1, 2], M. Shoaib Hanif[3].M.Saleem Khan[3]. Otto Koudelka[1]
Institute of Communication Networks and satellite Communications,TU Graz, Austria[1]
[2]Department of Electrical Engineering, University of Mmanagement and Technology, Lahore. [2]
Department of Computer Sciences, Government College University, Lahore, Pakistan. [3]
Corresponding Authors: tahirmushtaq2006@yahoo.com , shoaibkw@gmail.com,mskgcu@yahoo.com
koudelka@tugraz.at

ABSTRACT: *the problem of spectrum scarcity becomes with the new devices and applications of wireless communication. The solution of this problem is the cognitive radio Networks. This paper presents the different scheduling techniques for the secondary user and evaluated the results of maximum throughput and optimal resource utilization based on evaluation results of different scheduling techniques introduced at that time for cognitive radio networks. The research proposes one of the key challenges in spectrum sharing that is spectrum scheduling. And on the base of these results we evaluated that spectrum scheduling for secondary user is the key factor for maximum throughput and optimal resource utilization in cognitive radio networks.*

Keywords: cognitive radio, spectrum sharing, spectrum holes, resource utilization.

INTRODUCTION:

Studies done for the spectrum utilization in different countries including United Kingdom and United States shows that licensed bands are underutilized and most of the radio frequency spectrum bands are free for most of the time [1].The FCC report published in 2002 shows that licensed bands are utilized from 15% up to 85% [2].In unlicensed band congestion is increasing rapidly. The ISM bands are Overcrowded due to WLAN, Bluetooth, cordless phones, microwave ovens .Some other devices like armed forces, leisure radio, TV bands are mostly free and underutilized[2]. Different self-governing studies by different countries results that spectrum utilization is dependent on time and place [3].The reason of this varying underutilization of the Licensed Band Spectrum is the static allocation of the spectrum .

Fixed spectrum assignment prevents infrequently used radio spectrum from unlicensed user to hold this free frequency band, even their transmission cannot hold up at all with assigned spectrum. That's why unlicensed users must be allowed to use the licensed frequency bands with a condition that must not cause any harmful Interference due to licensed users. The priority of the primary user must be maintained.

.In this situation of inefficient RF Spectrum Utilization and Spectrum Scarcity, the scientists and Engineers are working on the designing of new paradigm.

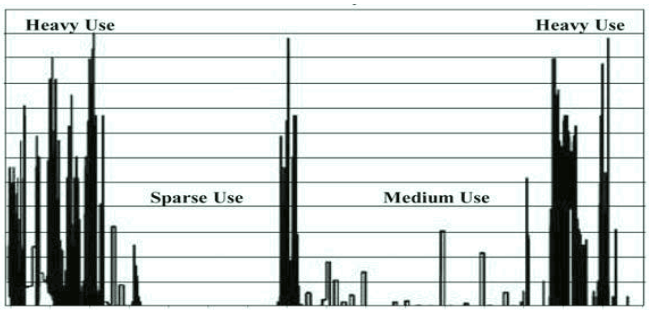

Fig1: fixed Spectrum utilization [3].

Joe Mittola introduced the concept of Cognitive Radio in 8 May,2002.Cognitive radio is a self-aware and intelligent devices which can sense the changing communication environment conditions. It can change its parameters like Frequency, modulation techniques, coding techniques, Power and so on according to statistical variations in the in the environment to maximize adaptively to ensure the efficient resource utilization and to ensure the QOS[4,5,6]. Self-awareness enables the cognitive Radio to learn from the network environments. Operations of the cognitive Radio are controlled *by the Cognitive Engine. Cognitive Engine works according to the cognitive Cycle. The cognitive cycle consists on the following steps as shown in Fig 2.*

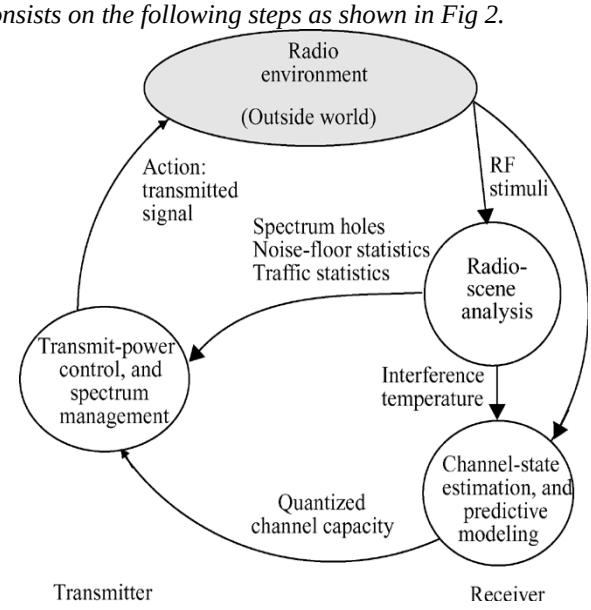

Fig2:Cognitive cycle reproduction from Figure 4-2[Mitola_00]

The primary users are the licensed users and they have the spectrum usage priority while 2ndary users (cognitive users) are unlicensed users which can sense the licensed bands and can access it in an opportunistic way [4, 6]. The main tasks of the cognitive cycle are

Spectrum Sensing:

Detection of free spectrum holes and sharing of this unused spectrum without any interruption to the other users is called spectrum sensing. Detection of primary users is the best way to find the free spectrum holes in spectrum sensing [6].

Spectrum Management:

Spectrum Management is classified into spectrum analysis and spectrum decision for capturing the best available unused spectrum to complete the user communication requirements. Cognitive radio has to decide the best spectrum band to meet the Quality of Service requirements.

Spectrum Mobility:

Cognitive radio uses the free spectrum dynamically to use the best available unused spectrum that's why cognitive user has to exchange its spectrum frequency to the best spectrum. This process of exchanging spectrum is spectrum mobility [6].

Spectrum Sharing:

Taking of best scheduling technique for cognitive users refers to spectrum sharing. Spectrum sharing is the key challenge for free spectrum allocation in cognitive radio networks.

Cognitive radio can utilize the spectrum holes by sensing and adapting the environment and serve the cognitive users without interrupting the licensed user [7]. Each licensed user has a specific licensed channel so can send data to these channels but secondary users don't have any licensed channel that's why has to access opportunistically to unused spectrum hole to send data. Primary user are considered as static because they don't change their channel but the secondary user are assumed to be dynamic because they can change set of channels over the time.

PROBLEM FORMULATION:

It is necessary for a cognitive radio to access any available channel from the targeted free spectrum band, make possible network communication by operating complete or specific part of the channel, sharing the free spectrum among secondary users by applying the scheduling techniques, and error correction schemes to obtain the best throughput.

The new emerging practice to maximize the utilization of the spectrum band is the cognitive radio network. Cognitive radio network utilize the spectrum that is not being used by the primary user and can dynamically access operating points from the wide range of free spectrum available at that time. If we have a network based on access points, have both primary users those are licensed to specific spectrum and the mobile secondary users those access the spectrum holes opportunistically. In this network primary users don't need to wait or schedule for data transmission and can send data on their licensed channel at any time when they desires. Because secondary users don't have any licensed channel like primary user so for the communication they have to wait for the spectrum that is free from primary user and can opportunistically access this free spectrum. To avoid from the interference among the cognitive users we need to implement sophisticated scheduling technique. The implementation of reliable scheduling technique is much necessary because the throughput of the network is dependent on this technique. Best technique used for scheduling will increase the network throughput as well as optimal utilization of the resources of the network is possible.

PERFORMANCE ANALYSIS:

The underlying challenge is to determine intelligently which and when users can access the allocated spectrum bands or channels to transmit their packets. In data networks, the packet scheduler is important for resource management. It needs to account for unique characteristics of time-varying and location-dependent channel conditions. The recent research shows that the overall system performance, such as the system throughput, fairness, delay, and loss rate, will be significantly affected by the scheduling policy being used [8].Many scheduling schemes have been proposed to address the resource allocation problem for traditional wireless networks as well as cognitive radio networks.

A scheduling policy has two contradictory goals:

To maximize the overall net-work throughput and another is the optimal resource utilization (to guarantee fairness amongst users).

In opportunistic scheduling maximum collision constraint with primary user is consider to increase the throughput of secondary user [9]. For designing online flow control, scheduling of cognitive users resource allocation for maximum resource utilization **Lyapunov optimization** technique is used. On the base of knowledge of channel conditions, sensing periods can adaptively scheduled to maximize the spectrum of the cognitive radio [10].

Each secondary user observes channel conditions, channel status (occupied or free) and channel quality. Then based on **queue size** and **observed channel status** each secondary user will estimate the throughput for each channel over the frame to be scheduled and will access the channel that have maximum throughput for this user. This technique of scheduling is applied to increase the aggregate throughput of Cognitive users [11].

RESULTS & DISCUSSION:

Spectrum scheduling simulations results and effects are discussed here. Fig3.shows the plotted total average congestion verses input rate. The simulations are done for greater than 6, 00,000 time slots. Each data point and each curve corresponds to different control parameters V that is 10 and V = 1 mean no flow control and f1 .In this scenario total average occupancy goes to maximum without any limit till the input rate reach to maximum network capacity. The vertical line which is approximately at 0.590 packets per slot represents the value.

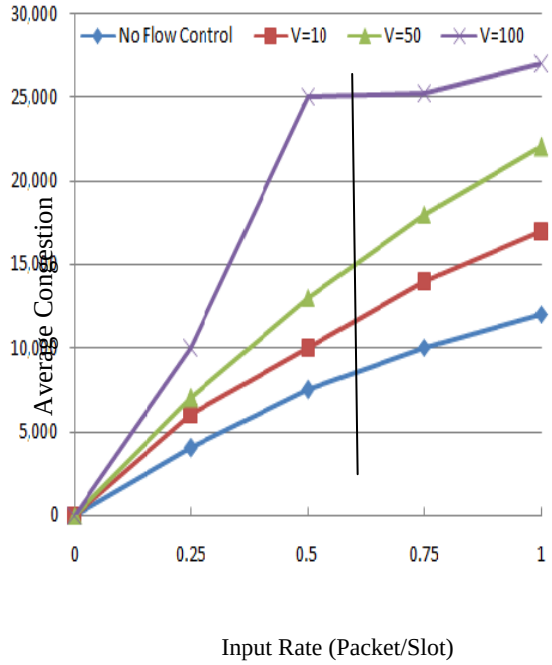

Fig 3. Total average congestion vs. Input rate for different V

Fig 4shows the comparison between the attained throughput and unrefined data input rate for changing values of V. For the small values of V, resultant throughput is similar to the input rate.

The throughput saturation depends on the value of V and goes to maximum when V is very large and capacity level is about 0.75 as shown in figure 2. The throughput gradually increases till it reaches its maximum level and after that different input values it become identical.

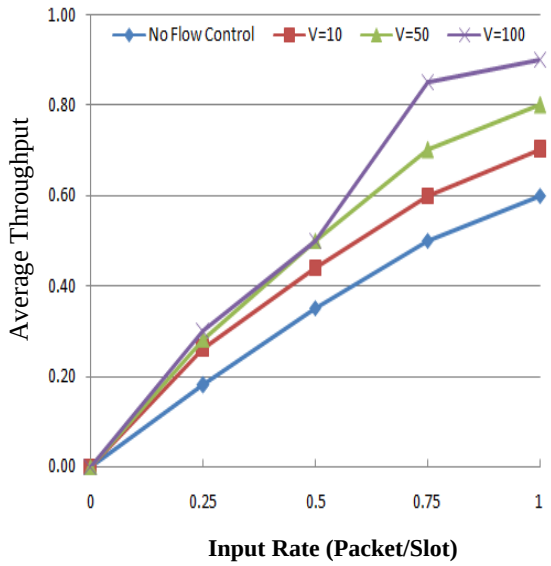

Fig 4.Achieved throughput vs. input rate for different values of v

Fig. 5 shows **average throughput** go to its maximum when frame size **N**= 4 and channels **U = 8** and **10** channels. It had also illustrates that average throughput increase when **N= 6** slots for 8 and 10 channels. By using present scheduling algorithm higher throughput can be achieved.

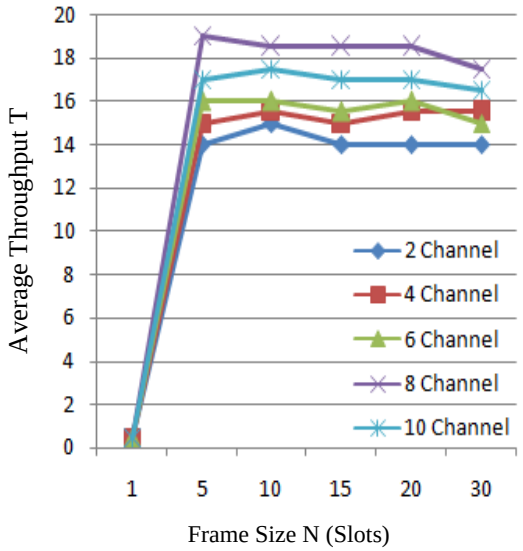

Fig5 .Throughput T vs. frame size N for different configurations.

Many other scheduling techniques are introduced by different researchers. The common goal of cognitive radio networks research community is maximization of the network throughput and optimal utilization of the network resources.

CONCLUSION:

The above simulation results show it clearly that maximum throughput of CRN and optimal utilization of the resources is dependent on the scheduling technique used for the Cognitive radio network's users. The performance criterion for scheduling technique is the maximization of the network throughput and best utilization of the network resources. The network community is concentrating on the CR networks for the next generation intelligent networks.

Various spectrum scheduling techniques are in progress in Adaptive Control System Research Lab, Department of Computer Science work on. The motto behind the designing of new scheduling techniques is the maximum overall throughout of the cognitive radio network. The cognitive radio networks are designed for the 802.11(g) devices.

ACKNOWLEDGEMENT:

We want to say special thanks to Higher education commission of Pakistan, Computer Science Department,GC University Lahore ,OeAD Austria and Institute of Satellite Communication and Networks for their marvellous help in the research ,study and stay in Austria.

REFERENCES:

[1]Michael Calabrese,the End of Spectrum 'Scarcity': Building on the TV Bands Database to Access Unused Public Airwaves, New America Foundation June 2009.

[2] Federal communications commission spectrum policy task force November 15,2002

[3] VáclavValenta et al., Survey on Spectrum Utilization in Europe: Measurements, Analyses and Observations

[4]s.Haykin,''cognitive radio: Brain empowered wireless communications'',IEEE journal on selected Areas in Communications,Vol.23,no.2,PP201-220,Feb 2005

[5] Jon M.Peha Sharing Spectrum through Spectrum policy reform and Cognitive Radio

[6] J. Mitola, *Cognitive radio: An integrated agent architecture for softwaredefinedradio*, Doctor of Technology, KTH, Sweden, 2000

[7] C. Sun, W. Z. (2007, June). Cluster-based cooperative spectrum sensing in cognitive radio systems. IEEE International Conference Communication, 24-28.

[8] S. Lu, V. Bharghavan, and R. Srikant.Fair scheduling in wireless packet networks. IEEE/ACM Trans. Networking, 7(4):473{489, Aug. 1999.

[9]Rahul Urgaonkar, Michael J. Neely. Opportunistic Scheduling with Reliability Guarantees in Cognitive Radio Networks.IEEE INFOCOM, PHOENIX, AZ, APRIL 2008

[10] A T Hoang, Y Liang, Y Zeng. Adaptive Joint Scheduling of Spectrum Sensing and Data Transmission in Cognitive Radio Networks, IEEE Transactions on communications, VOL. 58, NO. 1, Jan 2010.

[11] T V Krishna, P wang, NDusit. An Opportunistic Spectrum Scheduling Scheme for Multi-channel Cognitive Radio Networks.School of Computer Engineering, Nanyang Technological University, Singapore.

[12] Ian F. Akyildiz, W.-Y. L. (2006, September 15). NeXt generation/dynamic spectrum access/cognitive radio wireless networks: A survey. Computer Networks, 50(13), 2127–2159.

[13] Anelisha D,S Biswas, S panda, A new fuzzy rule based specturm utilization and specturm management for cognitive radio. National Conference on Electronics, Communication and Signal Processing, NCECS-2011, 19th September 2011

[14]J. Mitola. Software radios: wireless architecture for the 21st century. John Wiley & Sons Inc, 2000.