Performance Analysis of Cognitive Radio Networks (IEEE 802.22) for Various Network Traffics

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Abstract— In nowadays the number of wireless users and applications increases, it has become more and more difficult for the proper spectrum utilization by allocate frequencies. However measurements have shown that there is no spectrum scarcity; rather, there is inefficient utilization only. Cognitive Radio (CR) to facilitate efficient utilization of the radio spectrum in a fair-minded way and to provide highly reliable communication for all users of the networks. In this paper, a simulation framework based on NetSim simulator is proposed. This framework can be used to investigate and evaluate the impact of lower layers, i.e., data link layer and physical layer. Due to the importance of packet drop probability, delay and throughput as QoS requirements in real-time reliable applications, these metrics are evaluated over Cognitive Radio Networks (CRNs) through NetSim simulator. Our simulations demonstrate that the design of new networks over CRNs should be considered based on CR-related parameters such as activity model of Primary Users(PU), Secondary Users(SU),sensing time ,spectral efficiency, throughput, delay and Interference. An Analysis of the result shows that, the CBR traffic is the best in terms of throughput and spectral efficiency when the different conditions of PUs and SUs.

Keywords- *Cognitive Radio Networks (CRNs), Primary Users (PU), Secondary Users (SU), throughput, propagation delay, spectrum efficiency, Interference,Video,Audio,Constant Bit Rate(CBR)*

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I. INTRODUCTION

IEEE 802.22 Wireless Regional Area Networks (WRANs) are designed to provide broadband access to data networks. According to Federal communication (FCC) report[1],temporal and geographical variations in the utilization of the assigned spectrum range from 15% to 85% only. The WRAN systems will use vacant channels in the VHF and UHF bands allocated to the Television Broadcasting Service in the frequency range between 54 MHz and 862 MHz while avoiding interference to the broadcast incumbents in these bands. The wireless communication is known as opportunistic spectrum access and is a feature of Cognitive Radio. Cognitive radio refers to a smart radio that has the ability to sense the external environment and make intelligent decisions to adjust its transmission parameters according to the current state of the environment**.** Spectrum sharing is an important task of cognitive radio systems. Cognitive radio technology is predicted to change dynamic spectrum of networks. The spectrum is divided into licensed and unlicensed frequencies. The licensed spectrum is for the exclusive use of designated for primary users(PU) that utilizes UHF/VHF TV bands between 54 and 862 MHz .The unlicensed spectrum can be freely accessed by any secondary users(SU). SUs are equipped channel with cognitive radio capabilities to opportunistically access the spectrum. Cognitive radio capability allows SUs to temporarily access the PU's under-utilized licensed channels. To improve spectrum usage efficiency. PUs can access the wireless network resources according to their license while, cognitive radio must combine with intelligent management methods.

Cognitive Radio Process

CR is a radio that is able to sense the spectral environment over a wide frequency band and exploit this information to opportunistically provide wireless links that best meet the user communications requirements. CR provides the real-time interaction with its environment. This provides a way to dynamically adapt to the dynamic radio environment and the radio analyzes the spectrum characteristics and changes the parameters among the users that share the available spectrum. The goals of adaptation include spectral efficiency, minimizing interference to other CRs, coexistence of licensed users, etc. The environmental parameters that are continually sensed for adaptation include occupied radio frequency bands, user traffic, network state, etc. The CR consists of major components[2][3]:

 ISSN: 2321-8169
348 – 353

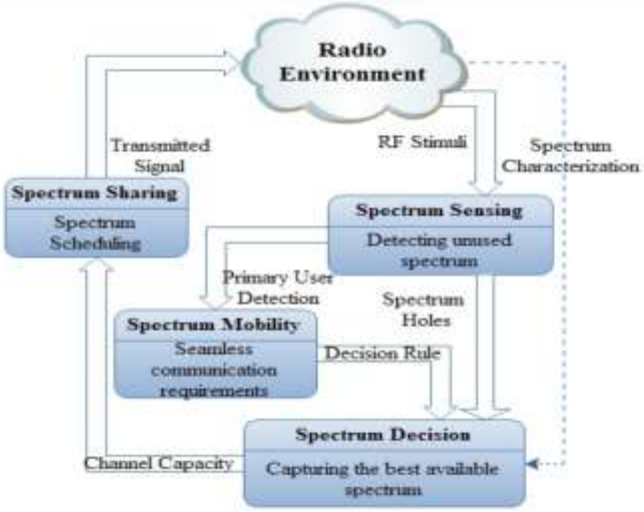

Figure 1.Cognitive Cycle

a) RF sensing. It refers to the estimation of the total interference in the radio environment, detection of the spectrum holes (or unused bands), estimation of the channel state information (i.e. SINR), and prediction of channel capacity for use by the transmitter.

b) Spectrum Decision: It is the task of capturing the best available spectrum to meet user communication requirements. These management functions can be classified as spectrum analysis spectrum decision.

c) **Spectrum Mobility**: It is defined as the process when a cognitive radio user exchanges its frequency of operation. Cognitive radio networks target to use the spectrum in a dynamic manner by allowing the radio terminals to operate in the best available frequency band, maintaining seamless communication requirements during the transition to better spectrum.

d) Spectrum Sharing: It refers to providing the fair spectrum scheduling method, one of the major challenges in open spectrum usage is the spectrum sharing.

II IMPORTANT COGNITIVE RADIO NETWORK PERAMETERS

a) **Interference time [4][5]**: It represents the interference time of the primary users (incumbents) with base station or cognitive radio CPE. The efficiency of spectrum sharing can be improved by minimizing the interference.

b) Propagation Delay [4]: Propagation delay is the amount of time taken for the signal to travel from the sender to the receiver over a medium. It can be computed as the ratio between the link length and the propagation speed over the specific medium.

$$\text{Propagation delay} = d / s$$

where **d** is the distance travelled and **s** is the propagation speed. In this work the number of Primary Users increases propagation delay. If the distance is decreased between secondary users (source and destination) then we can minimized delay.

c) Spectrum Efficiency(sη):

It refers to the information rate that can be transmitted over a given bandwidth in a specific communication system. It is a measure of how efficiently a limited frequency spectrum is utilized by the PUs and SUs with help of CR by using physical layer protocol, and media access control protocol.

d) End-to-End Delay: End-to-end delay is defined as the time for a packet to be transmitted from the source to the destination. The end-to-end delay is related to encoding/decoding delay, transmission delay, propagation delay, processing delay and queen delay. The end-to-end delay is an important parameter for real-time transmission because we want the voice stream is transmitted in the timely manner.

e) Delay [4]: It is the average amount of time taken calculated for all the packets to reach the destination from the source. This delay is related to the distance between the user and base station.

f) Throughput [4]: It is the rate of successfully transmitted data packets in unit time in the network during the simulation. The unit for throughput is usually bits per second. The maximum data rates of the TX and RX depend on the bandwidth of the circuits. The objective of the paper represents that improving the communications quality of the radio. Maximizing the throughput deals with the data throughput rate of the system. Total user data or payload delivered to their respective destination every second.

Throughput=

(Total payload delivered to destination (bytes)*8)/ Simulation time (micro seconds) Mbps.

III. NETWORK MODEL DESIGN AND DESCRIPTION

Our simulation approach uses NetSim simulator[5] for network modelling. NetSim is a popular network simulation tool used for design, planning and for network research and development. NetSim comes with an in-built development environment serving as an interface between User's code and NetSim's protocol libraries which are available as open C code for user modification, and simulation kernel. De-bugging custom code during simulation is an advanced feature where the users are allowed to perform single step, step in and step over which is carried out at various levels. NetSim is also proprietary software. The research area of Cognitive radio networks i.e Spectrum sensing & incumbent detection, Spectrum allocation, Geo location based services, Interference

ISSN: 2321-8169
348 – 353

analysis, measurement and modeling of spectrum usage and Protocol Architecture can also implemented through Net Sim simulator.

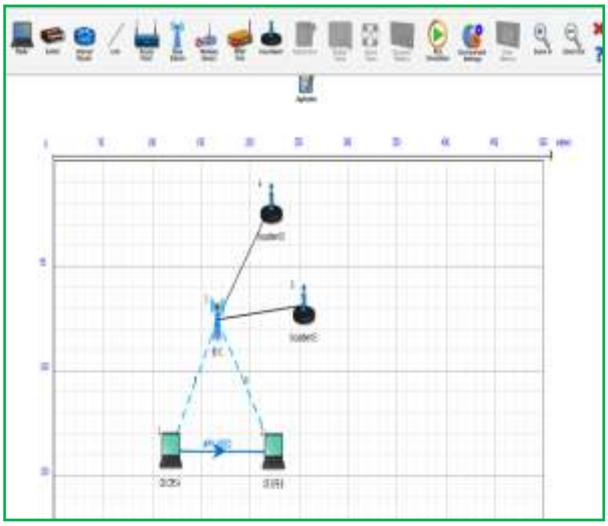

Figure 2.Network model of Cognitive Radio Networks

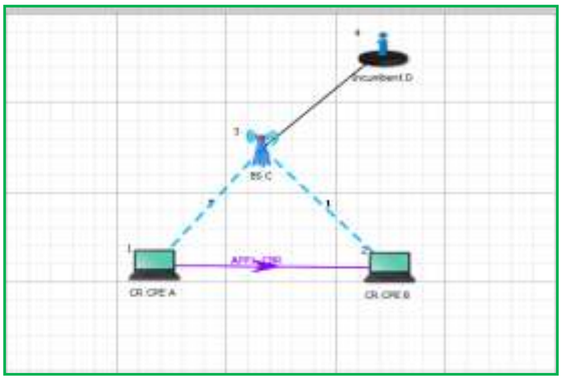

Figure 3. Network model of CBR traffic where PU<SU

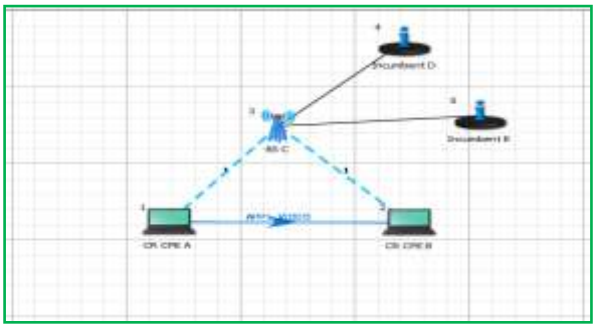

Figure 4.Network model of Video traffic when PU=SU

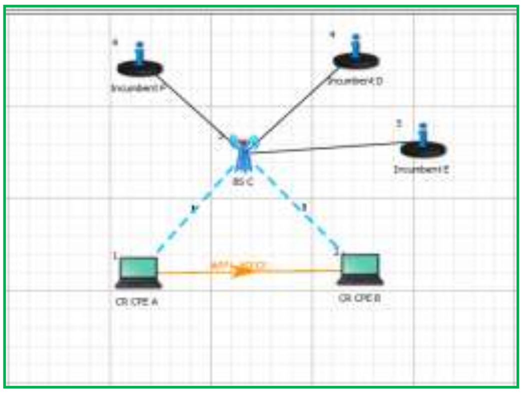

Figure 5. Network model of Voice traffic where PU>SU

.IV. SIMULATION RESULTS AND ANALYSIS

In our work three different scenarios with different traffics (Text, Audio and Video) have executed. In each scenario the Primary User is utilizing the frequency band of 54 - 60 MHz for 10 seconds after an interval of every 5 seconds. So the Secondary User uses this allocated frequency band of 54 - 60 MHz in an opportunistic manner i.e. during the interval of 5 seconds when Incumbent is not utilizing the channel, a spectrum hole is created and the Secondary User will utilize it to transmit data.

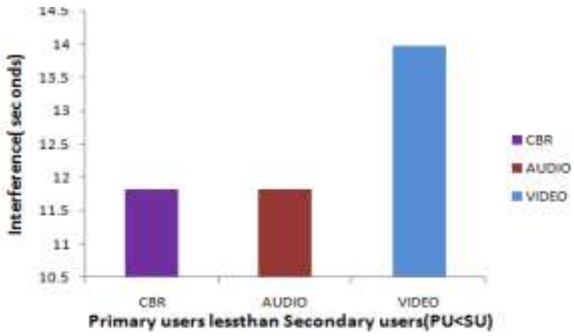

Figure 6. Interference when the traffic is CBR,Audio and video where PUs< SUs

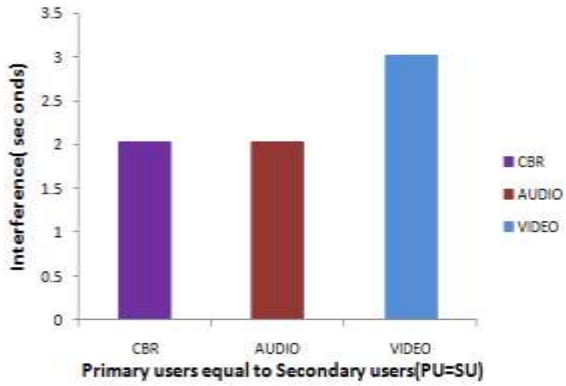

Figure 7. Interference when the traffic is CBR, Audio and video where PUs=SUs

ISSN: 2321-8169
348 – 353

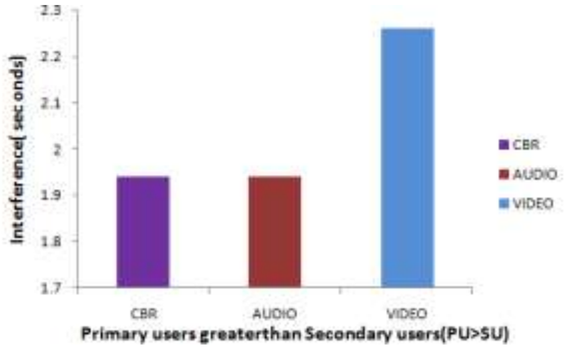

Figure 8. Interference when the traffic is CBR, Audio and video where PUs> SUs

The above figures shows the interference between primary users (incumbents) and secondary users in various scenarios i.e PU<SU,PU=SU and PU>SU at different traffics. In three conditions the interference more when the traffic is video transmitted from source to destination and comparing these three conditions interference more where number of primary users less than secondary users.

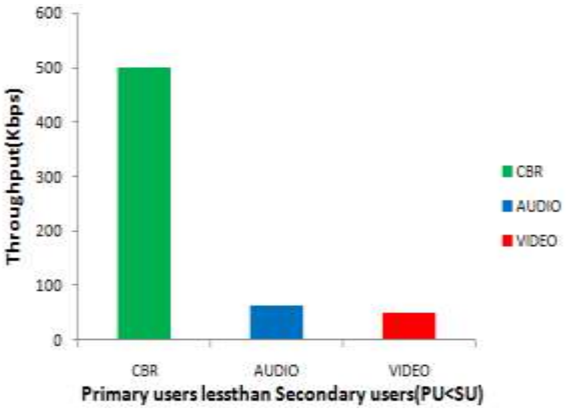

Figure 9. Throughput when the traffic is CBR, Audio and video where PUs< SUs

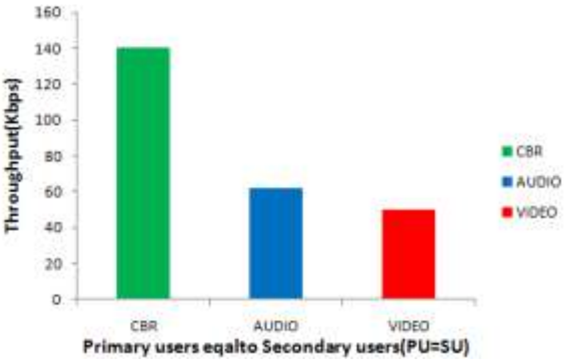

Figure 10. Throughput when the traffic is CBR, Audio and video where PUs= SUs

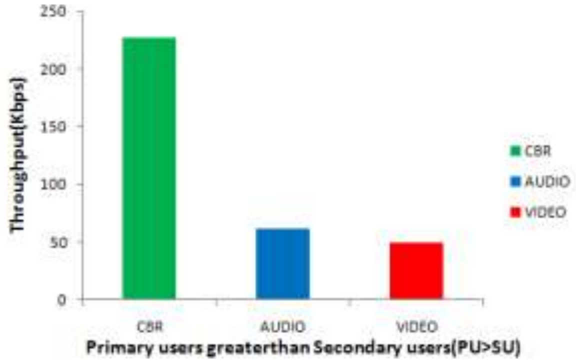

Figure 11. Throughput when the traffic is CBR, Audio and video where PUs> SUs

The above figures shows the throughput in various scenarios i.e PU<SU,PU=SU and PU>SU at different traffics. In three conditions the throughput is more when the traffic is CBR at number of primary users less than secondary users.

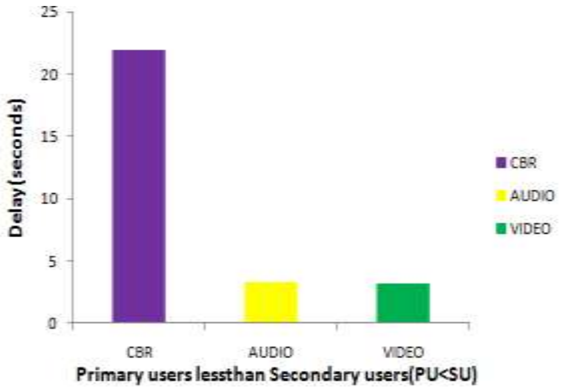

Figure 12. Delay when the traffic is CBR, Audio and video where PUs< SUs

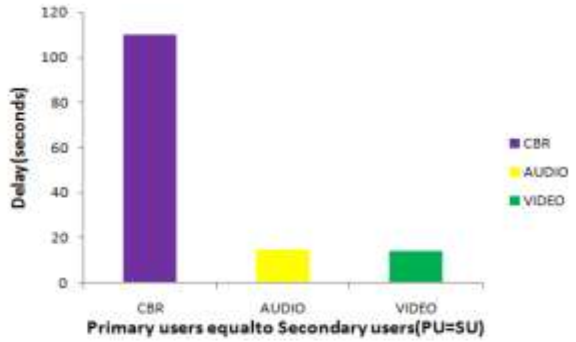

Figure 13. Delay when the traffic is CBR, Audio and video where PUs= SUs

ISSN: 2321-8169
348 – 353

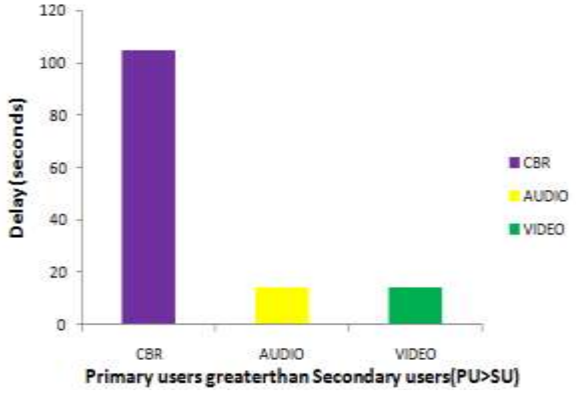

Figure 13. Delay when the traffic is CBR, Audio and video where PUs>SUs

The above figures shows the delay between source and destination in various scenarios ie PU<SU,PU=SU and PU>SU at different traffics. In three conditions the delay is more when the CBR traffic is transmitted from source to destination and comparing these three conditions delay is less where number of primary users less than the number of secondary users.

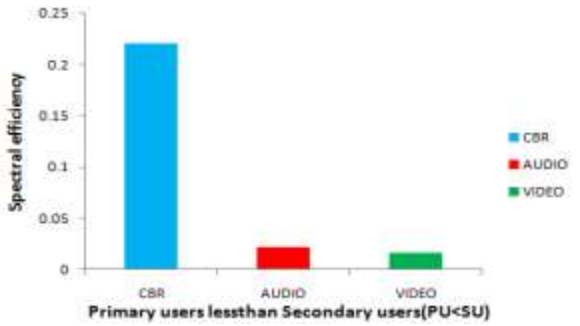

Figure 14. Spectral efficiency when the traffic is CBR, Audio and video where PUs< SUs

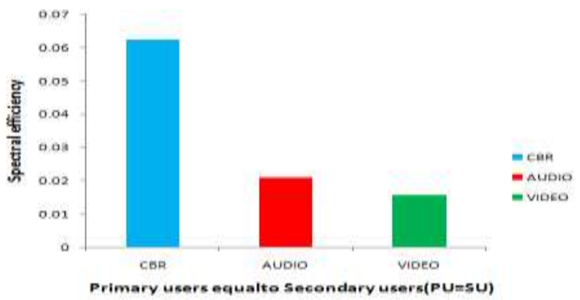

Figure 15. spectral efficiency when the traffic is CBR, Audio and video where PUs=SUs

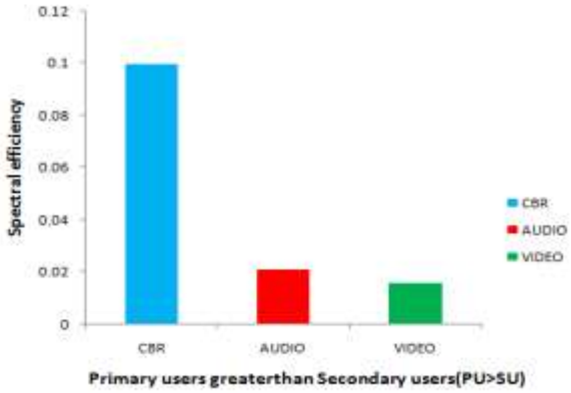

Figure 16.Spectral efficiency when the traffic is CBR, Audio and video where PUs> SUs

Spectrum efficiency is high where the traffic is CBR and the condition is number of primary users are less than secondary users when comparing to audios.

Table 1 Simulation parameters

Modulation	QPSK,
Type of traffic	CBR,AUDIO,VIDEO
Operating frequency of PU and SU	54-60Mhz
Operational_Time	10Seconds
Operational_Interval between PU and SU	5 Seconds
Distance between PU and SU	100m
Simulation time	300seconds
Channel bandwidth	6KHz
Channel characteristics	Fading and shadowing

V CONCLUSION

Experimental results reveals that in each scenario CBR has the best traffic at the condition is number of primary users(PUs)less than Secondary users(SUs) and the performance of its QOS parameters are varies with different network traffics. we conclude that the number of primary users increases, when the PUs greater than SUs then the delay is increased, through put and interference is decreased.

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