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A Test bed Using USRP and LabVIEW for Cognitive Radio Technology

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Abstract: In cognitive radio network, dynamic spectrum access is considered as the base which allows unlicensed secondary user (SUs) to access licensed spectrum allotted to licensed primary users (PUs). SUs identify the idle band and access them without interfering in primary users (PUs). For peer-to-peer based communication in dynamic in dynamic spectrum access. SU transmitter and SU receiver should use same channel to communicate. In case of jamming attacks and wideband regime fixed common control channel are not viable. When SU transmitter and SU receiver identify idle channels, they use best channels, they use best channel to communicate [1]. SDR (Software defined radio) or CR (cognitive radio) courses are offered in many universities but due to insufficient hardware available for experimentation [2], these are mainly restricted to theoretical studies. In order to implement these system for validation an expensive set of equipments are necessary. Also the signal is virtually processed and recorded for later time. These issues were resolved by a new technology that provided real time signaling. The universal software radio peripheral (USRP) based system we are describing addresses all of the previously mentioned problems. Specifically,

a. USRP systems are affordable than original hardware [3].

b. Real time signaling is achieved by connecting hardware with windows support device and then operating it with software support system i.e. Lab VIEW [4].

c. USRP systems are easier to learn, install and configure in a hardware compatible device [5].

Keywords: Universal software radio peripherals (USRPs), LabVIEW, Real Time Signalling

I. INTRODUCTION

Recent technological growth has enabled many electronic devices to connect to the Internet simultaneously. Due to this unprecedented growth in the field of wireless networking technology, these electronic devices that were not able to communicate to the internet in the past are now able to connect and share the vast wealth of information using wireless technology.

Exponential increase in number of devices, users and wireless traffic, wireless service providers are facing spectrum drought. However, recent studies show that the spectrum scarcity is created by static spectrum allocation policy. Dynamic spectrum access (DSA) in cognitive radio networks (CRN) is regarded as a solution for spectrum scarcity created by the static spectrum allocation policy.

In CRN, instead of relying solely on dedicated spectrum as in traditional wireless networks, cognitive radios can tap into the resources of licensed primary users to share with the unlicensed secondary users. Invention of smart radio technology to handle bandwidth will be must in the future as it has been estimated that by the end of 2020, 50 billion devices will be connected to the internet through Internet of every Things (IoT). DSA in CRN is carried out in such a way that the SUs should not create any harmful interference to PUs. In this case SUs should scan the channel to find idle bands and use those idle bands to communicate with their intended receivers.

When transmitter and its receiver are located in two different locations and want to communicate with each other, they need to find idle channels. Then, they need to establish a communication link in a suitable channel using common control channel. However, use of common control channel in wideband regime for DSA in CRN is not feasible and most importantly use of common control channel is vulnerable to jamming attacks. Thus, SU transmitter and receiver pair needs to establish a link on the fly to establish a communications link using rendezvous methods. In this thesis, we present a small scale test bed for rendezvous for SUs using the National Instruments USRP™ for peer-to-peer based communication using DSA in CRN. We program USRP units using LabVIEW and MATLAB scripting extensions to tune transmit parameters such as transmit power, channels, sample rate, etc. We assume that the USRPs (i.e., SUs) have idle channel information but they need to find the common channel among idle ones to communicate with each other in cognitive radio ad hoc networks.

II. COGNITIVE RADIOS

Cognitive radios are the radio systems that autonomously coordinate the usage of radio band. They recognize radio spectrum when it is unused by the incumbent radio system and use this spectrum in an intelligent way. Such unused

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radio spectrum is called 'spectrum opportunity,' also known to as 'white space'. The idea of cognitive radio (CR) was first presented officially in an article by Joseph Mitola III and Gerald Q. Maguire, Jr in 1999. It was a new approach in wireless communications that Mitola described as: "The point in which wireless personal digital assistants (PDAs) and the related networks are sufficiently computationally intelligent about radio resources and related computer to- computer communications to detect user communications needs as a function of use context, and to provide radio resources and wireless services most appropriate to those needs" [6].

This is an intelligent wireless communication system that is cognizant of its surrounding environment and uses a understanding methodology by building to learn from the environment, adapt its internal states to statistical change in the incoming radio frequency stimuli by making corresponding variation in certain operating parameters in real time and with two primary objectives i) highly reliable communications whenever and wherever needed ii) efficient utilization of radio spectrum [7]

It was thought of an ideal goal towards which a software-defined radio (SDR) platform should develop: a fully reconfigurable wireless black-box that automatically varies its communication variables with network and user demands. [8] The difference between SDR and CR is shown in Fig. 1.

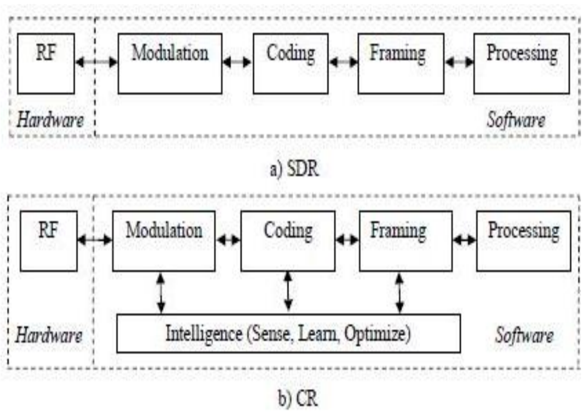

Fig. 1: Block diagram contrasting (a) SDR and (b) Cognitive Radio

Cognitive radio (CR) is a form of wireless communication in which a transceiver can intelligently detect communication channels which are in use and which are not, and instantly move into unused channels while avoiding occupied ones.

This optimizes the use of available radio-frequency spectrum while interference minimized to other users. CR technology is a paradigm for wireless communication in which transmission or reception parameters of network or wireless node are changed to communicate avoiding interference with licensed or unlicensed users.

III.LABVIEW (LABORATORY VIRTUAL INSTRUMENT ENGINEERING WORKBENCH)

LabVIEW (Laboratory Virtual Instrument Engineering Workbench) is a graphical programming environment which has become prevalent throughout research labs, academia and industry. It is a powerful and versatile analysis and instrumentation software system for measurement and automation. Its graphical programming language called G programming is performed using a graphical block diagram that compiles into machine code and eliminates a lot of the syntactical details.

LabVIEW offers more flexibility than standard laboratory instruments because it is software based. Using LabVIEW, the user can originate exactly the type of virtual instrument needed and programmers can easily view and modify data or control inputs. The popularity of the National Instruments LabVIEW graphical dataflow software for beginners and experienced programmers in so many different engineering applications and industries can be attributed to the software's intuitive graphical programming language used for automating measurement and control systems.

LabVIEW programs are called virtual instruments (VIs), because their appearance and operation imitate physical instruments like oscilloscopes. LabVIEW is designed to facilitate data collection and analysis, as well as offers numerous display options. With data collection, analysis and display combined in a flexible programming environment, the desktop computer functions as a dedicated measurement device. LabVIEW contains a comprehensive set of VIs and functions for acquiring, analyzing, displaying, and storing data, as well as tools to help you troubleshoot your code.

IV.NI USRP-2921

NI USRP-2921 software defined radio transceivers are designed for wireless communications teaching and research. Programmable with LabVIEW software, the USRP hardware is an affordable and easy-to-use RF platform for rapid prototyping applications such as record and playback, physical layer communication, spectrum monitoring, and more.

With the ability to transmit and receive RFsignals across a wide range of frequencies with up to 20 MHz of real-time bandwidth and plug-and-play MIMO support, the NI USRP enables a broad range of RF/communications applications covering common standards such as broadcast radio, digital TV, GSM Cellular, GPS, 802.11 (Wi-Fi) and ZigBee®.
LabVIEW brings increased productivity with an intuitive graphical programming approach, and m-file script compatibility enabling development of algorithms for physical layer communications.

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V. PACKET TRANSMITTER

A transmitter in LABVIEW is created for transmission of data in various modulation schemes. A descriptive block diagram is shown in Figure 60.

This model created in LABVIEW acts as a host based system code which interfaces with windows and USRP 2921 device. Using this code USRP acts as a transmitter and transmits data through the hardware antenna in programmed modulation schemes [9]. The block diagram shows packet transmitter.

This coding is further described into sub sections along with major blocks performing various functions as shown in Fig.2- Fig.7.

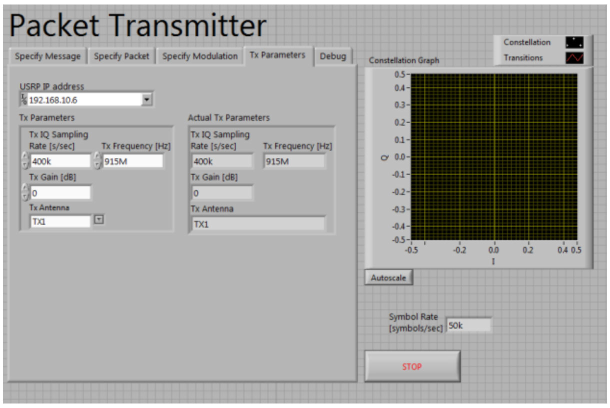

Fig.2: Packet Transmitter (Tx Parameters)

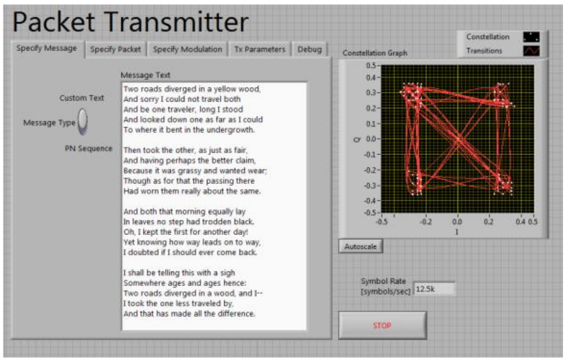

Fig.3: Packet Transmitter (Specify Message)

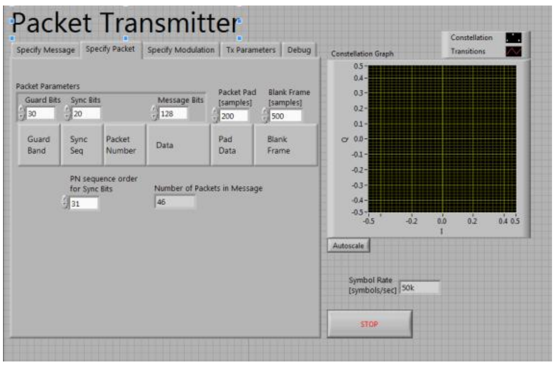

Fig. 4: Packet Transmitter (Specify Packet)

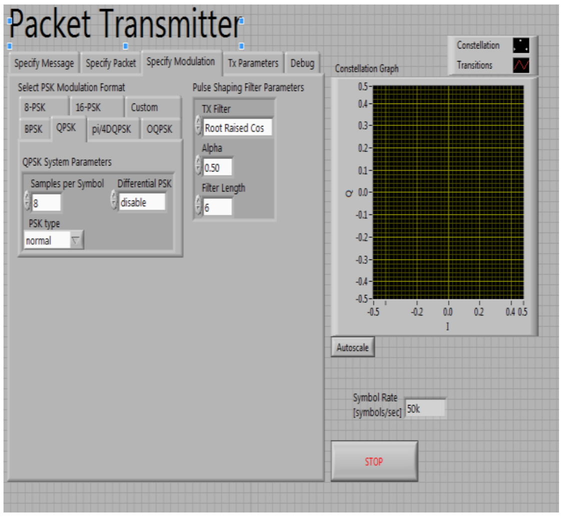

Fig.5: Packet Transmitter (Specify Modulation)

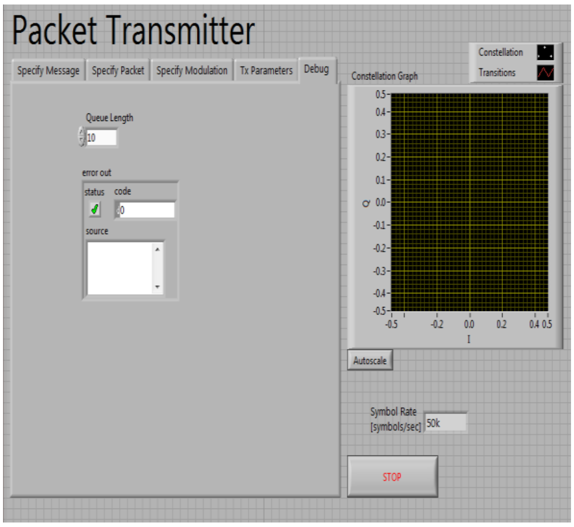

Fig.6: Packet Transmitter (Debug)

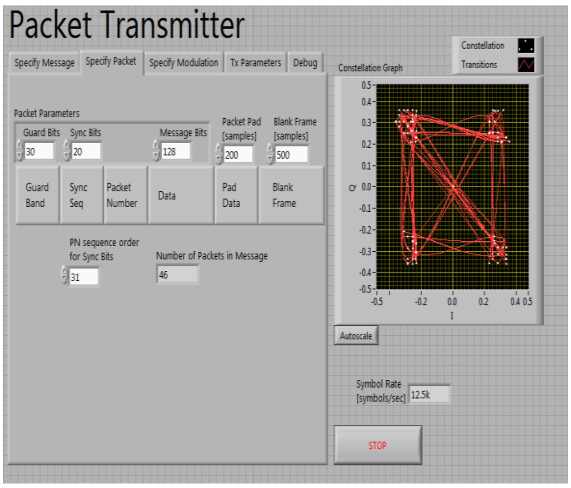

Fig. 7: Packet Transmitter (Final Transmitted Output)

Each of the above front panel view shows how we have direct access to various parameters which can be altered during transmission of data.

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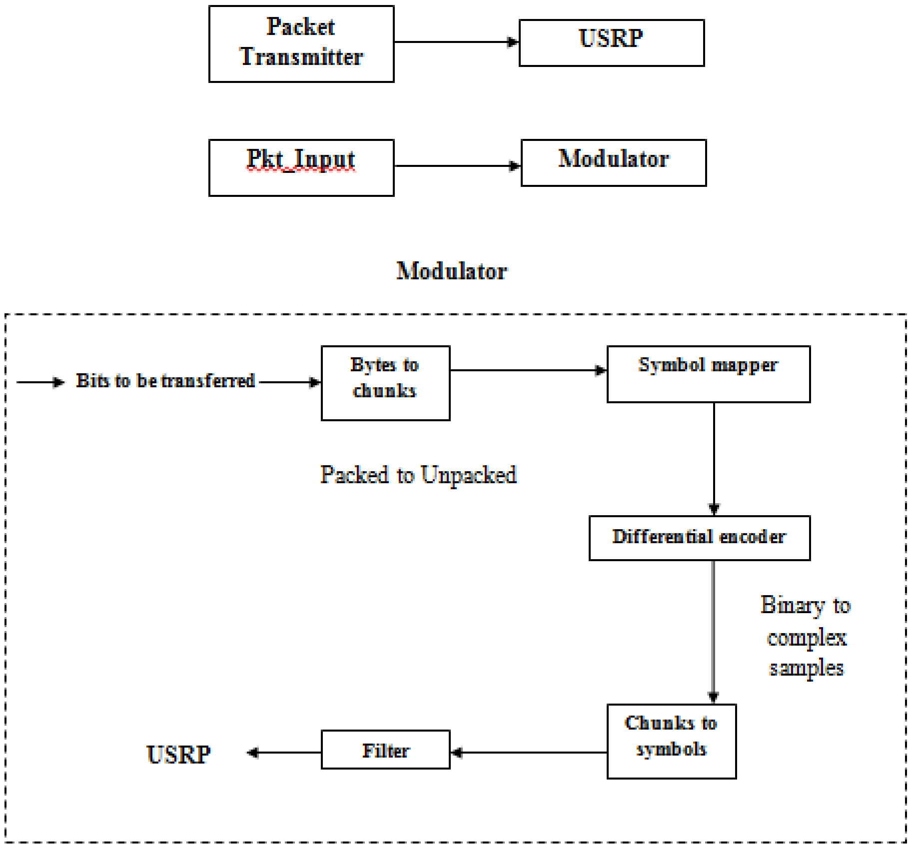

Fig. 8: Flow Graph for Transmitter in LABVIEW

VI. PACKET RECEIVER

Transmitted signal sent via USRP is received with another USRP device, similar to transmitter block diagram a separate block diagram for receiver is created which will receive signal that is sent on ISM band. Block diagram of code created on lab view is shown in Figure. The signal is received by USRP device and processed by receiver block in LabVIEW. Transmitter block was programmed using PSK modulators which were used to transmit signal as shown in Fig.9-Fig.13.This receiver section has PSK demodulator which will decode the signal [10].

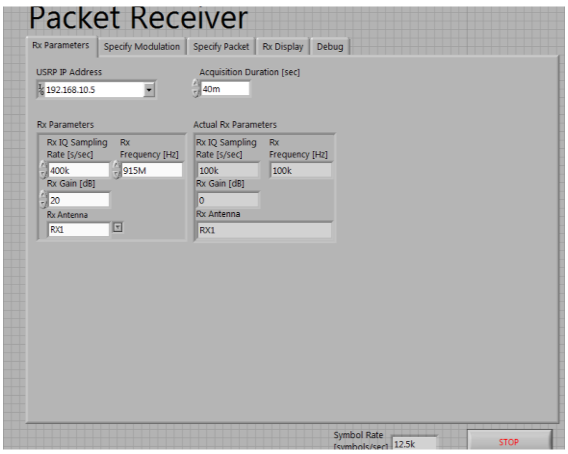

Fig. 9: Packet Receiver (Rx Parameters)

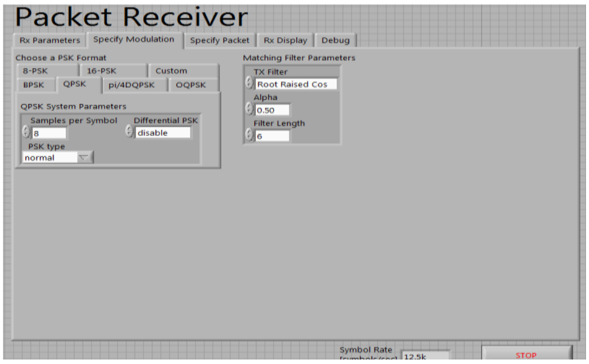

Fig. 10: Packet Receiver (Specify Modulation)

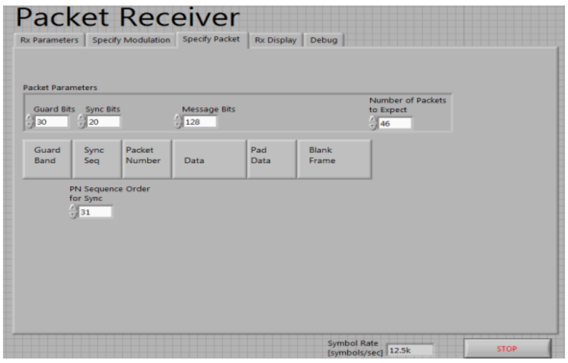

Fig. 11: Packet Receiver (Specify Packet)

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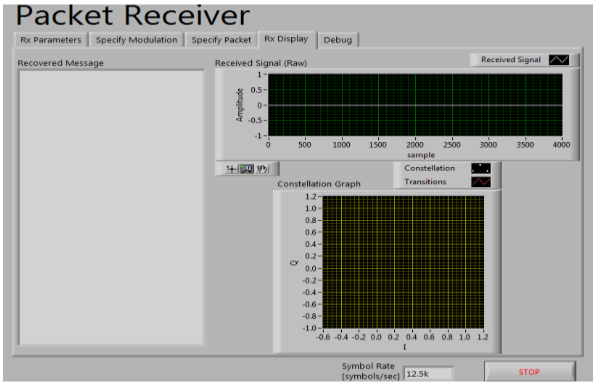

Fig. 12: Packet Receiver (Rx Display)

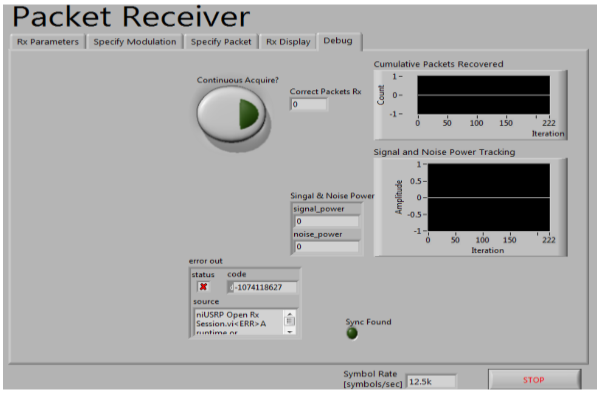

Fig. 13: Packet Receiver (Debug)

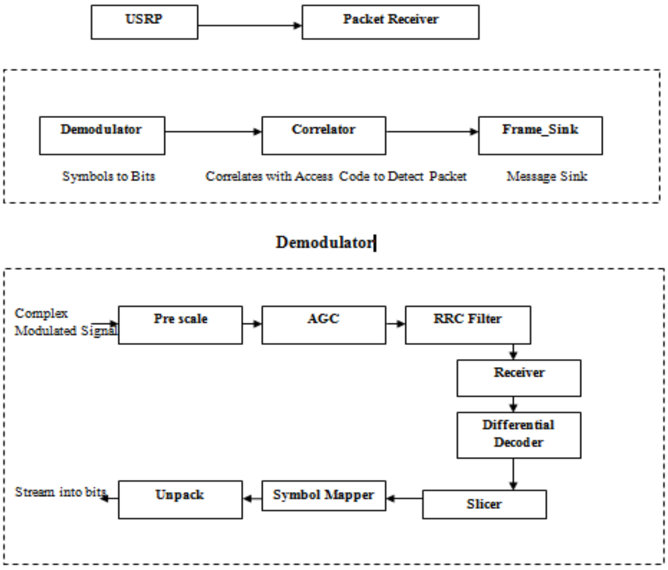

Fig. 14: Flow Graph for Transmitter in LABVIEW

VII. RESULTS: REAL TIME SIGNAL

The following section shows various modulation schemes and their comparative transmission and reception in ISM band. Following Figure s show transmitted and received signals established through a communication link using USRP devices.

8 PSK Modulation (Fig. 15)

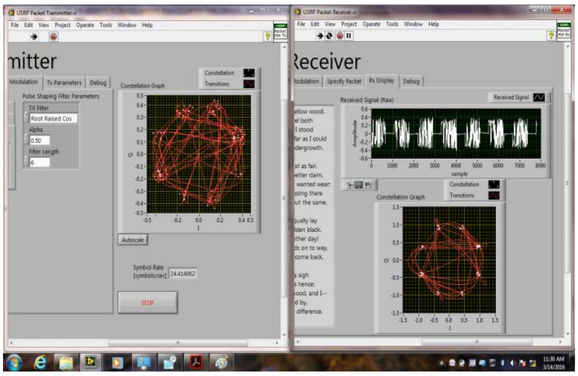

Fig. 15: Transmitted and received signal of 8 PSK

VIII. CONCLUSION

The USRP (universal software radio peripheral) hardware is an efficient platform to transmit and receive data over a wide range of frequencies. Recent developments in LabVIEW have enabled us to perform demonstrative projects in real time signalling. Rapid increase in researches can be assembled and implemented using LabVIEW and the USRPs which is cost efficient and easier to access than traditional devices. This research helped us understand minimum interference offered while data transmission and reception using USRP which also explained comparisons of various packet transreceiver modulation schemes. Signal transmission from one PC to another PC is a tedious task. Using USRP, this work can be accomplished in a simple and cost effective manner. By networking the computers using the switch along with USRP, real time communication experiments can be performed. In recent scenario, a USRP platform is designed to enable students and professionals to explore and experiment with the multidisciplinary facets of wireless communication. This is likely to cause a revolution in communication engineering education. A cognitive radio must create as little interference as possible to the primary user of the band. The cognitive system implemented for this thesis works according to this specification finds a free band over ISM band for secondary user to transmit data over it.

IX. FUTURE SCOPE

This research can be further extended to any other real time modulation system. USRP is evolving as a fine hardware that can be used academically as well as professionally. Advanced and complex researches are easier to implement using this hardware support. Communications education is enhanced using combination of the LabVIEW/USRP which increases opportunities of capstone design projects and cutting- edge research. This is a low cost system which has hands-on approach with realistic/real-world demonstrations using live signals in laboratory exercises.
Also DSA model in LabVIEW can be implemented to other modulation schemes and variable frequency with another set of USRP devices. In the current implementation, if the number of channels is large, the receiver will spend a lot of time cycling through the channels to find the transmitter. An improvement to the system would be to include a power detector in the cognitive receiver.

The cognitive transmitter will then send warning packets for a long time and the algorithm for synchronization will not be efficient. If a power detector is added, the receiver will only dwell on the channels with a high power and will not waste time looking for the transmitter on channels with low power. The hidden node problem still remains: if the primary user is close to the cognitive receiver but far away from the cognitive transmitter, then the transmitter will not detect the primary user and will transmit.

The receiver will not receive the packets correctly because of the presence of the licensed user. In order to overcome this problem, the receiver must acknowledge it received packets but then, the overhead is increased. Cooperative sensing is also a potential solution to this problem. OFDM should ideally be used in the cognitive transmitter instead of phase shift keying because the bandwidth occupied by this transmission can be changed dynamically to match the available bandwidth.

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BIOGRAPHIES

S. Promika received the B.E. degree in electronics and communication engineering from the Chandigarh College of Engineering and Technology, Chandigarh, India, in 2013.Currently doing M.E. in electronics and communication engineering (M.E. ELECTRONICS) in PEC University of Technology, Chandigarh, India. Her research interest includes Cognitive Radio technology (Dynamic Spectrum Access), USRP and cognitive radio networks.

M. Rita received B.E (E&EC) Degree from Thapar University, Patiala in 1986 and her M.E. (Electronics) in 1993 from PEC University of Technology (formerly known as Punjab Engineering College) Chandigarh, India. She has got 25 years of teaching experience and published more than 25 papers in International and National journals and conferences. Her research interests include neural networks, VLSI and cognitive radios.