Open Source Software Defined Radio Using GNU Radio And USRP

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Abstract: In today's era, development in wireless communication systems has now become an emerging field for research. Now every user requires high data rate having low cost with greater efficiency. To achieve all this requirements in current communication system we have to make lot of hardware change in systems. So instead of using current communication system we are using cognitive radio approach which helps us to achieve greater flexibility and robustness. By implementing SDR we are replacing hardware part by software. GNU radio is open source, so we chose GNU radio and a device named Universal Software Radio Peripheral (USRP). SDR is more flexible as compared to conventional radio and can perform signal processing having low latency at the minimum cost. Thus by implementing SDR we spectrum mobility can be achieved.

Index Terms: Cognitive Radio Network, GNU Radio, Next Generation network, Relay network, Software defined radio, USRP

1 INTRODUCTION

We propose to implement high stability ubiquitous wireless communications among software defined radio nodes which are open source reconfigurable RF Devices. We are using GNU radio and universal software radio peripherals (USRPs) to set up cognitive relay network to provide effective communication among wireless node. Software defined radios can implement different standards on the same system allowing dynamic configuration resulting in seamless network access with the help of reconfigurable RF device like USRP to communication on two frequency ranges. We also believe that use of open source GNU radio will enhance the appeal and utility of the RF devices.

1.1 Cognitive Radio Network

The next generation networks used for dynamic access of spectrum is termed as cognitive radio networks. Our spectrums are controlled by government authorities. They give spectrum on lease basis over a larger geographical area. As we are assigning spectrum on larger area the use of spectrum gets more sporadic. Actually spectrum uses is more concentrated on certain areas only where it causes more traffic while in their area it is remain unused. It causes underutilization of spectrum.

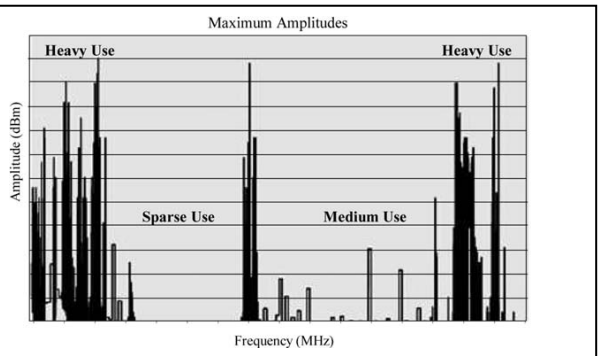

Fig. 1. Sporadicity in Spectrum Use

Government assigns spectrum on the basis of fixed spectrum access policy. Policy authorities of spectrum management assigns spectrum of certain bandwidth to one or more users. Due to this only limited number of people who have license get permission to access those spectrums. As this policy is used all over the world spectrum is getting extinguished as well as available in limited manner. To overcome the problem of spectrum scarcity we have to use dynamic spectrum access policy with help of cognitive radio network (CRN). There are two main features of cognitive radio:-

1. Cognitive capability

It means capability to sense the information from radio environment and select the appropriate parameters for usability.

2. Re-Configurability

It provides ability to dynamically programmed according to radio environment.

1.2 Next Generation Network

It is also called as dynamic spectrum access networks or cognitive radio technology which provides high bandwidth to mobile users. It uses heterogeneous wireless technology and dynamic or opportunistic routing technique to access the spectrum. Efficiency of spectrum can be improved by opportunistically accessing of licensed band without interfering the current user. to use the next generation network, important aspect is cognitive radio network. Cognitive radio network will provide ability to use, access and switch spectrum dynamically.

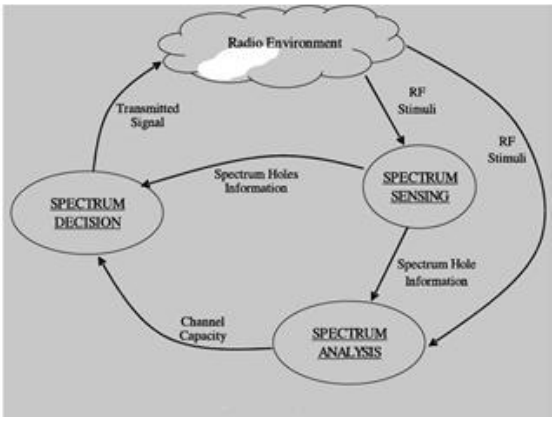

Fig. 2. Cognitive Cycle

The four important functions of cognitive radio network in next generation network are:

1. Spectrum sensing

With the help of cognitive radio users can decide which portion of spectrum is currently available and also let the users know if

any licensed user is present.

2. Spectrum management
After sensing the spectrum it will select the best available channel.

3. Spectrum sharing
Co-ordinate access with other users and maintains seamless communication with other users.

4. Spectrum mobility
Immediate evacuate the channel when licensed user is detected.

2 Software Defined Radio

Software Radio is ultimate device where antenna is connected directly to Analog to Digital Convertors (ADC) / Digital to Analog Convertors (DAC) and all signal processing is done digitally using field programmable high speed DSP. Due to this filtering ,modes of operation can be easily changed depending upon need & new technology ,so all these function are automatically control in software rather than hardware . SDR is Radio communication system where component (e.g. mixers, filters, amplifiers, modulator/demodulator, detectors) that been USUALLY in hardware are instead implemented by software on PCs or embedded system. SDR have significant utility for military and cell phone service both of which serve a wide range of changing radio protocol in real time. once the functionality of radio component are implemented on software environment there are additional advantages gained such as greater flexibility & SDR can be flexible enough to avoid the limited spectrum. Another benefit from using software is that the data processing may be performed with any general purpose computer, eliminating the need to buy expensive specialized Hardware. In academia, a majority of learning and research in digital communication involve developing software using computer. Thus SDR is very beneficial for educational institute where components are plenty but the budget for supplementary hardware is modest. As shown in fig, in case of SDR system the transducers ,source encoder/decoder, channel encoder/decoder and digital modulator/demodulator block may be defined in software and ADC/DAC ,RF front block can accomplished in hardware, for this Relay communication system is implemented using GNU Radio, software kit and USRP. Thus SDR minimizes the hardware to provide faster modification, easier prototyping, lower cost, greater flexibility and reusability.

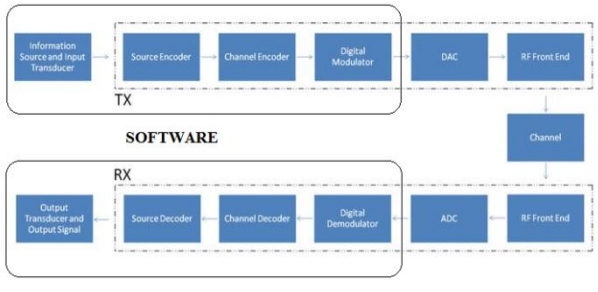

Fig. 3. Software Defined Radio

3 Universal Software Radio Peripheral

When we discuss about GNU Radio, the Universal Software Radio Peripheral (USRP) board is one of the most important hardware module. It is developed by Matt Ettus mostly for the users of GNU radio. USRP is a unified board which integrates digital-to-analog converters (DAC) and analog-to-digital converters (ADC), RF front end, and an FPGA which performs some significant preprocessing of the input signal. The USRP is high speed and low -cost, that's why a GNU Radio User prefers to implement real time applications. Basically USRP board consists of a mother board and maximum four daughter boards. ADCs / DACs: USRP consist of four 12-bit ADCs and four 14-bit DACs of very high-speed having sampling frequency 64M S/s at the receiving path and 128M S/s at the transmitting path respectively. It also consists of a programmable gain amplifier (PGA) before the ADCs to utilize entire input range of ADCs and also after DACs for providing gain. PGAs on transmitter as well as receiver routes are programmable. The Daughter Boards: There are four slots on the mother board, which can be used to connect up to 2 RX daughter boards as well as 2 TX daughter boards. The daughter boards can be utilized to hold the RF receiver and RF transmitter. FPGA: It performs high bandwidth arithmetic to diminish the data rates. The FPGA links to the Cypress FX2, which makes use of the USB interface.

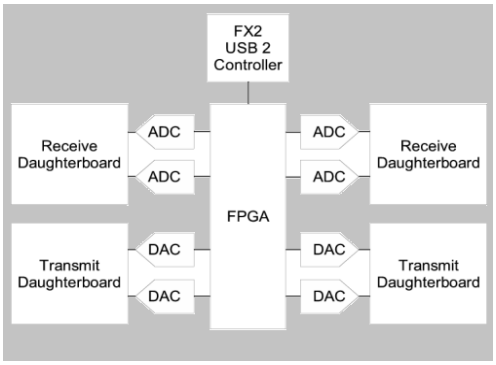

Fig. 4. Block Diagram for USRP

4 GNU Radio

GNU Radio is a free as well as open source software development toolkit that offers signal processing blocks to implement SDR. GNU Radio performs all the signal processing. As GNU Radio is A software that can handle only digital data. So we can use it to write applications to transmit and receive data into digital form. GNU Radio has filters, channel encoders, modulators, demodulators which are typically found in radio system. The best thing about GNU Radio is that it not only provides method of connecting the signal processing blocks but also accomplishes the data that is passed from one block to another.

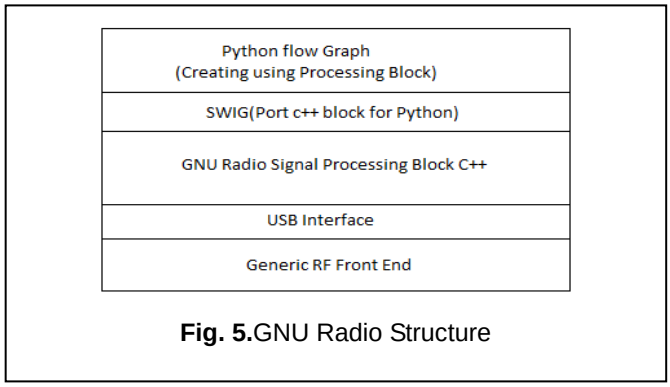

Fig. 5.GNU Radio Structure

Mainly python programming language is used for writing various gnu radio applications, while C++ language is used for performance-critical signal processing path using processor floating point extensions, where available. Thus, the developer can easily implement real-time, high-throughput radio systems in a simple-to-use, rapid-application-development environment In order to implement SDR, GNU Radio is used along with external RF hardware. In our case we are using universal software radio peripheral as a RF hardware.

5 Relay Network Experimental Setup

In this works, Fig. shows the experimental setup for the experimental study of SDR test-bed implementation utilizing GNU Radio and USRP. Here we are implementing a relay network. A relay node is an intermediate node between sender and receiver. Three USRP and three PC's having GNU Radio installed were used to run these experiments. Each PC is connected with a USRP, making a node in the network. Daughter boards used for these experiments are SBX which can cover frequencies from 400 MHz to 4.4GHz. Sender will send data over a frequency entered by user. Sender and receiver are far placed from each other such that reception is poor. Indoor area is considered for this experiment with the distance of TX USRP and Rx USRP is 30 m2.

5.1 Transmitter

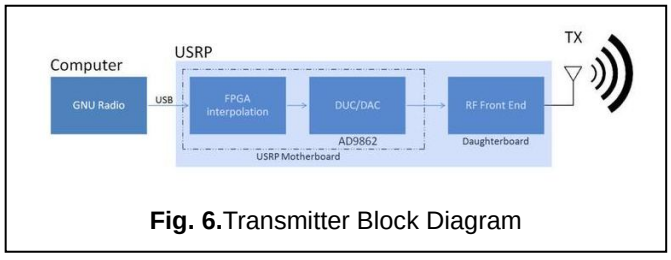

Fig. 6. Transmitter Block Diagram

Fig. shows the transmitter blocks. basically it consists of the data packet block, the modulator block, and the USRP block. The daughter board SBX can transmit and receive signal in the frequency range 400MHz - 4.4GHz and we have used DBPSK modulator use in this experiment. Ethernet helps in collaborating with GNU radio and the USRP. Finally USRP will transmit the signal in the desired frequency through its daughter board.

Algorithm:

1. Start
2. Accept file path (to send) from user.
3. Accept transmission frequency from user.
4. Convert input data into packets.
5. Modulate data using DBPSK modulator.
6. Send packets over a specified frequency.
7. Stop.

5.2 Receiver

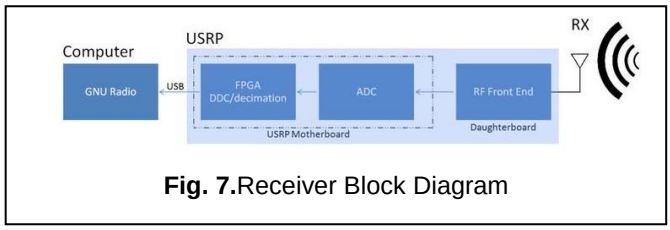

Fig. 7. Receiver Block Diagram

Block diagram of the SDR receiver has shown below. The signal produced by daughter board (SBX) will be transformed to the IF frequency and then sampled by the ADC on the USRP. Then inside the FPGA, it will be decimated by the DDC and sent to the GNU Radio through Ethernet The bit stream from USRP is demodulated by the DBPSK demodulator block and then passed to the Co-relator to detect the start and end of packet. Then the received data will be shown through a graph (amplitude vs. frequency).

Algorithm:

1. Start
2. Accept file path (to save) from user.
3. Accept reception frequency from user.
4. Start accepting data.
5. Demodulate data using DBPSK demodulator.
6. Combine packets into a file.
7. Stop

5.3 Relay Node

The relay node is introduced between sender and receiver. Basically relay node is used for either to amplify the signal or when transmitter and receiver are far placed. The relay node will accept data from transmitter and will send to the receiver over a different frequency. Frequencies for operation will be chosen by user.

5 Conclusion

This paper clarifies that open source software defined radio are being developed to solve the current issues of wireless networks resulting from inadequate spectrum availability and inefficient use of spectrum with the help of GNU radio and USRP. With the help of cognitive radio we can access spectrum dynamically. We also discussed about the various applications that can be huge advantage over current communication applications.

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