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Review Article

A REVIEW ON IMPLEMENTATION OF COGNITIVE RADIO IN ISM BAND (2.4 GHZ)

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Abstract:

Cognitive radio has been considered as a promising technology for solving the problem spectrum underutilization. It allows the users to identify the spectrum opportunities and interference free spectrum sharing. It operates in the environment which is complex. However implementing cognitive radio in real time is difficult and expensive. In this paper we discuss the various implementation methods of cognitive radio network in reconfigurable platform.

Keywords: Cognitive Radio, Implementation.

Introduction:

Cognitive Radio acts as an important role in today's wireless communication. With the ever increasing demand for wireless communications, the spectrum has become a scarce resource. Cognitive Radio (CR) is one of the major technologies to solve the problem of spectrum scarcity. It allows the users to use the spectrum effectively. To implement in real time it is quite complex. We will discuss the various methods how they have implemented. Adaptive Adhoc Free-band (AAF) project, an emergency network built on top of Cognitive Radio is proposed. New functional requirements and system specifications for Cognitive Radio have supported by a reconfigurable architecture proposing a heterogeneous reconfigurable System-on-Chip (SoC) architecture to enable the evolution from the traditional software defined radio to Cognitive Radio. The heterogeneous reconfigurable architecture includes heterogeneous processing elements such as general purpose processors (GPP) and ASICs. A key element in this heterogeneous reconfigurable architecture is the Domain-Specific Reconfigurable Hardware (DSRH), which can achieve the re-configurability in combination with the energy efficiency. A Domain-Specific Reconfigurable Hardware (DSRH) core, called Montium. A design methodology is needed to map applications onto a heterogeneous platform which has two new features:

transaction level modeling of applications and run-time spatial mapping.[1] Cognitive radio is a novel approach to improve the spectrum usage, which can sense the spectrum and adapt its transmission while coexisting with the licensed spectrum user. A reconfigurable radio platform is required to provide enough adaptively for cognitive radio. Cognitive radio system architecture is proposed and discussed its possible implementation on a heterogeneous reconfigurable radio platform. Using the concept of cognitive radio and discussed its possible implementation on a heterogeneous reconfigurable radio platform. Cognitive radio is aimed to solve the spectrum scarcity problem caused by the regulatory spectrum allocation. It may be a good candidate for future mobile systems considering that more and more wireless systems to use the spectrum. However, cognitive radio is only in its initial stage, and many questions are answered. Many new research projects start to investigate this topic. Our research is under the Adaptive Ad-hoc Free-band (AAF) project sponsored by Free-band Organization in the Netherlands. In future, we aim to come up with detailed system architecture and sets of algorithms for cognitive radio. The ultimate goal is to build a heterogeneous reconfigurable radio platform to demonstrate the cognitive radio functionalities.[2]

Current research is investigating different techniques of using cognitive radio to reuse locally unused spectrum. They also aim to develop efficient algorithm able to maximize the quality of service (QoS) for the secondary (unlicensed) users while minimizing the interference to the primary -X? (licensed) users. However, there are many challenges across all layers of a cognitive radio system design, from its application to its implementation. Cognitive radios have to face very challenging issues like designing blind wideband sensing algorithms efficient interference management strategies and distributed collaborative communication able to guarantee opportunistic "Sustainable" communication. Technological challenges concern the design of spectrally-agile components and architectures in the radio-frequency front-end of the transceiver able to support flexible wideband multi-band communication mechanisms.[3]

Using high-level FPGA-based cognitive radio framework for implementing a video transmission over a frequency-agile radio link. It uses spectrum sensing to detect the transmission frequency and adapts the forward error correction scheme to the channel conditions autonomously.

Spectrum sensing and adaptive forward error correction are two examples of features required in cognitive nodes, which are the building blocks of autonomous, self-organizing networks in future wireless systems. The demonstrator described shows a wireless video streaming application over an adaptive, frequency-agile communications channel. The receiver can find the transmission frequency without prior information, at start-up or when the frequency changes. The forward error correction scheme adapts to current channel conditions at run-time, by partially reconfiguring the FPGA hardware transparently, as required.[4]

Proposing a novel design methodology, along with a flexible software/hardware system and associated high-level tools for the implementation of cognitive radios on modern Field Programmable Gate Arrays (FPGAs). The platform presented can be used by wireless communication engineers with no hardware design experience. An initial case study was demonstrating the cognitive radio for a real-time application. Utilizing the high performance, power efficiency and flexibility features of modem FPGAs. The system can handle parts of the radio being implemented in hardware with other parts in software. A composer capable of automatically deciding the hardware/software partitioning of radio components in a given chain, while hiding the implementation details from the radio designer. An initial case study successfully demonstrated the platform's use in a live audio transmission application. One key point for future work is the implementation and test of the composer. We envisage that the developed platform will prove useful to the research and commercial communities in helping cognitive radios become a reality.[5]

Identifying the important features a cognitive radio framework should provide, namely a virtual architecture for hardware abstraction, an adaptive run-time system for managing cognition, and high-level design tools for cognitive radio development. Evaluating a range of existing frameworks on these, and propose a novel FPGA-based framework that provides all these features. By abstracting away the details of hardware reconfiguration, radio designers can implement FPGA-based cognitive nodes much as they would do for a software implementation. The proposed framework to the design and implementation of a receiver node that works in two modes: discovery, where it uses spectrum sensing to find a radio transmission, and communication, in which it receives and demodulates the said transmission.

The major requirements for a cognitive radios development framework have been identified and implemented in the proposed framework, targeting Xilinx FPGAs. The novel framework consists of three key building blocks: a virtual architecture for hardware abstraction, an adaptive run-time system for managing cognition, and high-level design tools for cognitive radio development. The computational performance and run-time partial re-configurability of FPGAs were harnessed, while the low-level implementation details were hidden from the designer. That is, the designer is focused on the development of the cognitive radio functionality (i.e., radio chains and cognitive engine), and not in the low-level FPGA implementation details.

The cognitive engine was implemented in software (i.e., embedded PowerPC), without being aware of where the specific components of the processing chain were implemented (i.e., embedded PowerPC or FPGA logic fabric). Using an example cognitive receiver implementation that switches between spectrum sensing and a receiving mode on the same FPGA device, we have demonstrated the framework's capabilities.[6]

New communication models based on FPGA have been designed, and new algorithms of RFFE (RF Front End) model have been advanced. Then, performance analysis has been worked on this model. Moreover last, FPGA is used for the host CPU in this model, and DSP is used for the coprocessor to deal with the software and signals. Results show that the hardware monitor is enhanced, and the throughput is improved. Moreover, the system cost and the operating power are reduced in this model.

Cognitive radio (CR) is an emerging intelligence wireless communication technology, transceiver platforms have been proposed, and the model has been designed based on FPGA. The platform model's functions have been analyzed, and the defect has been proposed. Moreover, the defects have been solved by the high-speed computing power of DSP. Meantime, in our system FPGA has been used to be the general purpose processor and DSP has been used to be the coprocessor to process software data. Under the new system, the function has been enhanced, the throughputs have been improved, the hardware cost have been decreased, and the system power have been reduced, so it is a realizable model during the environments of CR.[7]

The frequency spectrum is one of the valuable resources in wireless communications. Spectrum efficiency will increase by making use of the spectrum holes. Dynamic Spectrum Access techniques allow secondary users to transmit on an empty channel not used by a primary user for a given time. In this paper, a Distributed Dynamic Spectrum Access based TDMA protocol (DDSAT) is designed and implemented on USRP. The proposed protocol performs two main functions: Spectrum Sensing, and Spectrum Management. Spectrum Sensing is used to find spectrum holes in a co-operative manner using the contributing secondary users. Spectrum Management works distributive on the secondary users to allocate the spectrum holes in a fairly and efficient utilization. The DDSAT protocol is implemented using Software Defined Radio (SDR) and Universal Software Radio Peripheral (USRP). Evaluation and performance tests are conducted to show throughput and fairness of the system.In this work, we designed a DDSAT protocol to allocate spectrum dynamically on a secondary network. The protocol performs a distributed dynamic spectrum access on a secondary network. Spectrum sensing is performed on each SN and shared between the different SNs to improve sensing decision.

Spectrum Sharing was performed through priority scheduling algorithm that calculates a relative priority between the SNs and allocates channel and time slots based on these relative priorities. The DDSAT protocol has been implemented using GNU Radio, and USRP N210 hardware platforms. Functional and performance evaluations were performed, where the protocol achieves fairness across the SNs and gives high spectrum sensing accuracy.[8] CORAL is a WiFi-based wireless terminal building block that can be used to implement cognitive radio networks (CRN).Cognitive capabilities were created by providing a PHY and MAC control framework around a standard off-the-shelf WiFi router containing multiple radios. Implementing a CRN that has sensing capability and can control radio emissions in space, time, and by channel in a manner that facilitates interference mitigation. Cognitive algorithms within CORAL can support learning, giving the CRN adaptive capabilities such as dynamic spectrum assessment and autonomous channel selection. The modular nature of CORAL allows implementation of radio topologies such as relay and mesh networks, as well as multipoint distribution networks. This simple but highly flexible radio system can implement many features identified by the ITU as important to Cognitive Radio and is intended to give researchers a viable platform on which to implement cognitive radio in an operational environment. The primary changes involved the imparting of a synchronization and radio transmission control scheme over the IEEE 802.11g DCF protocol and implementing a wireless sensor system that took advantage of the router's multiple radio capability. Creating a hybridized radio within which algorithms can be used to implement the adaptive and autonomous radio features as idealized by cognitive radio.[9]

The testbed is essential to advance the development of cognitive radio networks. Presenting a real-time testbed for the evaluation of the cognitive radio MAC algorithm. The testbed supports the necessary components of cognitive radio including programmable RF transceiver, software-defined MAC layer, and adaptive network layer to support multi-PU multi-SU cognitive radio networks. It is much easier to configure and control than the traditional FPGA-based testbed by using system-on-chip (SoC) programmable processors. The implementation details of the testbed to evaluate the performance of an adaptive CR MAC algorithm. The testbed was based on programmable SoC processors, CC1110, which makes it easier and more economical to deploy and evaluate cognitive radio network than the traditional testbed based on FPGA. The testbed enables the full control and online adjustment of PU and SU. The implementation details of spectrum sensing of PHY layer, the channel selection strategy and the access control strategy of MAC layer. With such a testbed, we experiment the proposed adaptive MAC algorithm and prove the cognitive functions of our testbed.[10]

A Cognitive Radio is the final point of software defined radio platform evolution: a fully reconfigurable radio that changes its communication modules depending on network and/or user demands. His definition on reconfigurability is very broad, and we only focus on the heterogeneous reconfigurable hardware platform for Cognitive Radio. Software Defined Radio (SDR) basically, refers to a set of techniques that permit the reconfiguration of a communication system without the need to change any hardware system element. The goal of Software Defined Radio is to produce communication devices which can support several different services. These terminals must adapt their hardware structure in function of the wireless networks such as GSM, UMTS, wireless LAN standards like IEEE 802.11a/b/g As a consequence, NoC offer good perspectives to future SoC in the way to satisfy SDR concept. Conception, validation, and evaluation of solutions for NoC design (mapping of cores, topology, FIFO and link sizes) was conducted through simulations. To extend the NoC structure to an FPGA where PR (Partial Reconfiguration) is used to reconfigure dynamically the requested IP block of the telecommunication chain. This work is part of our contribution. The partial reconfiguration flow with simple resource but the methodology could have extended to any other resource, like an FFT for example. Future works on this study plan to use the OPBHWICAP implementing the ICAP in 32bits mode to decrease reconfiguration time. We are also working on partial reconfiguration flow using a heterogeneous platform (DSP and FPGA) using Syndex tool for reallocation of resources.[11]

The peak data rate from 3G UMTS to 4G LTE-Advanced only increases 55 percent annually, while global mobile traffic has increased 66 times with an annual growth rate of 131 percent between 2008 and 2013. To provide abundant new spectrum opportunities by exploiting underutilized or unutilized spectrum opportunistically. The technical solutions to expand LTE spectrum with CR technology (LTE-CR), and survey the advances in LTE-CR from both research and implementation aspects. We present detailed key technologies that enable LTE-CR in the TV white space (TVWS), and related standards and regulation progress. To demonstrate the feasibility of deploying LTECR in TVWS, we have conducted extensive system-level simulations and also developed an LTE-CR prototype. Both simulation and laboratory testing results show that applying LTECR in TVWS can achieve satisfactory performance.

The application of CR technology will resolve the dilemma between the increasing spectrum demands and the spectrum resource shortage. The research community, industry, and standards and regulation bodies are all making progress on CR over white space, especially TVWS. This article discusses the major technical solutions to expand LTE spectrum into TVWS with CR technology and presents the advances in LTE-CR from both the research and implementation aspects.

Detailed key technologies that enable LTE-CR in TVWS and related standards and regulation progress were presented. Extensive system-level simulations and laboratory prototype testing results have validated the feasibility of deploying LTE-CR in TVWS.[12]. Spider Radio, software-defined the cognitive radio (CR) prototype for dynamic spectrum access (DSA) networking. The medium access control (MAC) layer of SpiderRadio was implemented in software on top of commodity IEEE 802.11a/b/g hardware. However, the architecture and implementation apply to other spectrum bands as well. A dynamic spectrum sensing methodology for primary, incumbent primary detection. The method is based on observing the PHY errors, received signal strength and statistical model building. For coordination among radio nodes, synchronization, and fast channel switching, presenting new communication protocols, design extended management frame structure and modify the hardware abstraction layer. Several fundamental tradeoffs (e.g., complexity versus network performance) have been considered during a dynamic spectrum access radio network prototype implementation were also discussed. To demonstrate the practical capabilities of the proposed SpiderRadio prototype also, present various test bed experimental measurement results. Spider Radio demonstrates that software abstraction of MAC layer implemented on commodity hardware is a feasible option for dynamic spectrum access networking. By treating the commodity wireless network interface card as a black box, it is possible to design and implement the quick and reliable spectrum sensing algorithms that exploit the inherent characteristics of the interface. Fast channel switching has been implemented with negligible synchronization failure probability using the software abstraction. High effective throughput is achievable using the implementation as seen in the experimental result.[13] A real-time cognitive radio network testbed was being built. First paper to capture the overall picture of this project. Project scope and philosophy, design architecture, hardware platform, and key algorithms were reported. The use of cognitive radio network for the smart grid is for the first time proposed in this paper. This unique testbed is ideal for such purpose. Security and cognitive nature will be two focused issues. Especially, how to tie together these two issues. Both algorithms and hardware implementations have been explored. Many open problems have been reported elsewhere. For example, a critical decision is to decide on the two platforms (Lyrtech or USRP2). The unfriendly development environments of the Lyrtech platform and the associated high cost have major impacts on the future decision. Data was being collected from USRP2 nodes for this purpose. The goal of our in-house wideband radio platform is to explore the wideband nature of the cognitive radio. It will not be mature for the large-scale network testbed.[14] Presenting a wireless aircraft cabin system operating in the 2.4 GHz ISM band and uses cognitive radio techniques to increase system robustness by actively and dynamically avoiding interfering signals in the same frequency band. The implementation of the basic cognitive radio functions spectrum sensing, policy enforcement, and decision making, as well as their integration on a software defined radio platform together with the communication functions is presented and discussed. Finally, the cognitive approach is validated using a demonstrator setup and a controlled interference scenario

The development and implementation of a cognitive radio enable wireless cabin management system operating in the 2.4 GHz ISM band. Using spectrum sensing capabilities, the system can detect other wireless systems present in this frequency band and can determine potential interferers. A decision-making unit can, based on the spectrum sensing results and system constraints provided by a policy engine, decide on the most promising transmission channel for the wireless cabin management system and reconfigure the system to use this channel when certain decision criteria apply. With these cognitive features, the CWCMS can actively and dynamically avoid interferers to maintain system wireless communication. These capabilities have been proven using a simple test scenario with controlled interferences.[15]

Introducing and implementing a new dual mode spectrum sensing technique based on combining Quickest Detection with Energy Detection. Our dual mode system introduces a compromise between speed and complexity. When the SNR goes below the SNR wall for the low complexity energy detection, our system switches to the more expensive quickest detection based algorithm. A practical prototype of our system is implemented on the WARP FPGA-based nodes to study its efficiency and complexity. In addition to practical experimental results, we derive theoretically closed form expressions for the probability of false alarm and the probability of detection for our new approach. Our quickest detection algorithm is a technique that minimizes the sensing time which allows for higher spectrum efficiency. However, it has a higher implementation complexity than the conventional ED approach. We first derived a closed form expression for the probability of false alarm as well as the probability of detection for our quickest detection algorithm. We then numerically computed its SNR wall. We then presented a new technique that compromises speed and complexity based on FPGA implementation results. Our dual mode spectrum sensing system uses ED as long as the SNR is higher than the ED’s SNR wall, which in our case is 3dB. Once the received SNR was dropped below the ED’s SNR wall, our technique automatically switches to the quickest detection algorithm that can operate efficiently all the way to SNR = −6dB. We also found out from our FPGA design, that an excess of 32 samples is required as processing cost to implement our quickest detection algorithm.[16]. Presenting a real-time hardware implementation of spectrum sensing based energy detection (SSED) with diversity reception techniques. The paper mainly focused on selection combining

(SC) and equal gain combining (EGC) to improve the probability of detection for spectrum sensing purpose in cognitive radio network (CRN). The performance of a system was evaluated in real-time over Rayleigh environment based FPGA (field programmable gate array) platform. The DVB-T (digital video broadcasting - terrestrial) signal in 2k mode was considered a primary signal as specified in IEEE 802.22 WRAN (wireless regional area network) draft standard for re-using the very high frequency and ultrahigh frequency bands. The empirical results showed that performances of SS-ED with diversity reception techniques enhanced significantly, and they also matched with the theoretical analysis. Therefore, these techniques should be utilized to overcome the disadvantage of ED over Rayleigh fading channel. The SS-ED with reception diversity - SC or EGC for spectrum sensing has been designed on hardware platform using Stratix II EP2S180 board. The SS-ED algorithm with SC or EGC techniques was implemented in hardware device successfully. The empirical results showed that probability of detection increased dramatically by employ reception diversity techniques. Therefore, this scheme should be employed to overcome disadvantages of ED fading environment. We hope that this work could be a reliable hardware evidence for contribution to the IEEE 802.22 WRAN standard in the future.[17]

Proposed method:

Using tarang module we can implement the cognitive radio network. It operate within the ISM and 2.4-2.4835GHZ frequency band with IEEE802.15.4 baseband. Tarang modules are designed with low to medium transmit power and for high reliability wireless networks. The range for line of sight is up to 50kms with directional antenna. The transmit power is up to 1 watt/30dBm.the receiver sensitivity can be up to -107 dBm. The possible topologies are point to point, point to multipoint and peer to peer .the RF data rate can be 250 kbps. The number of channels for direct sequence is 16 channels. Generally command mode is used for reading or modifying the parameter of a module. Using Poisson distribution we can select the channel. It can occur 0, 1, 2 … times in an interval. The average number of channels in an interval is designed λ (lambda). Lambda is the channel rate, also called the rate parameter.

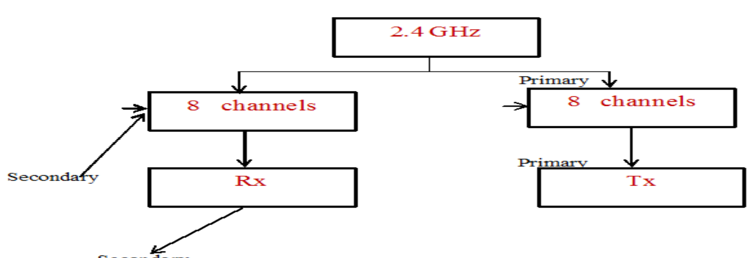

Fig :1. Proposed block diagram.

Conclusion:

The spectrum sharing plays a vital role in spectrum management in Cognitive Radio Network. The primary user and the secondary user have two forms: cooperation and co-existence. Here we consider Poisson distribution approach for dynamic spectrum access. The RF transponders are designed by using tarang module with an antenna. The antenna receives the signal from the environment. The signal strength and band allocation can be calculated for the different signal strength during transmission and receiving Process.

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