Alexandria University
Faculty of Engineering
Computer and Systems Engineering Department
CS 436 - Topics in Computer Networks

Radio K.A.O.S: Cognitive Radio with Dynamic Spectrum Sharing Engine

Project Progress Report

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1 GNU Radio

- Finished introductory tutorial on `https://gnuradio.org/redmine/projects/gnuradio/wiki/Guided_Tutorials` and learned how to use GNU Radio Companion.
- Implemented a couple of flow graphs to get used to the companion.

2 Readings

- T. Charles Clancy, Zhu Ji, Beibei Wang, K. J. Ray Liu. "*Planning Approach to Dynamic Spectrum Access in Cognitive Radio Networks*"
  Summary: In this paper, an implementation for a general-purpose cognitive radio engine is proposed. The CR engine shall consist of a knowledge base, reasoning engine, and learning engine:
  - Knowledge base: stores the semantics of dynamic spectrum access in action description language (ADL) as a set of facts and rules (actions).
  - Learning engine: manipulates the knowledge base from experience. Learning engine may only be run to train a newly initialized radio, or it could be run periodically as the radio operates.
  - Reasoning engine: executes the actions stored in the knowledge base. It keeps evaluating the objective function over all possible choices (all possible available bands and center frequencies). The goal of the objective function is to maximize capacity. A Primary-Prioritized Markov Approach (PPMA) for dynamic spectrum access is proposed, which is based on a fairly simple 8-state finite state machine. The interactions between the primary user (holder of licensed band) and the secondary users (unlicensed users) are modeled as a Primary-Prioritized Continuous-Time Markov Chain (PPCTMC).

- Usama Mir, Leila Merghem-Boulahia, Moez Esseghir, D. Gaiti. "*Dynamic spectrum sharing for cognitive radio networks using multiagent system*"
  Summary: The discusses the details of design of architecture for an ASIP (Application Specific Instruction Processor) for SDR (Software-Defined Radio) with a single bus and dedicated paths. The paper proposes an instruction set with the following instruction groups:

  1. Arithmetic copy/move instructions
  2. Integer arithmetic store with constant
  3. Floating-point Arithmetic store with constant
  4. Integer branch instructions
  5. Floating-point branch instructions
  6. Base-band and channel coding instructions

  Channel coding, decoding, modulation, and demodulation modules are all embedded in the ASIP.

- Thomas Charles Clancy III, "*Dynamic Spectrum Access in Cognitive Radio Networks*", Doctor of Philosophy thesis.
  Summary: I read Chapter 2 which introduces cognitive radio, explains information theory basics behind cognitive radio networks, and finally, shows various multiple access schemes for multiplexing users' communications.

- Upamanyu Madhow, "*Introduction to Communication Systems*"
  Summary: This is a textbook that articulates a selection of concepts that the author deems fundamental to communication system design. I read parts of chapter 3 [Analog Communications], and parts of chapter 4 [Digital Modulation].

3 FPGA

- Implemented VHDL code to transmit music over FM using FPGA. The code was tested using Spartan-3 FPGA and a radio receiver. This exercise gave us an idea about how FPGAs could be used to modulate and send radio waves.

4 USRPs

- On 14 April we have registered an account on SmartCI's Cognitive Radio Cloud (CRC). The CRC currently provides users with up to 5 USRPs, 8 wifi interfaces, and 8 RTLs.

- I learned how to use two of the USRPs to exhange signals: one could send a signal on a carrier frequency, and the other would sense the spectrum and detect a signal on the carrier. The 2 USRPs used where placed in the meeting room @ VTMENA second floor.