SPECTRUM ACCESS FOR FIRST RESPONDERS: A GENERAL OVERVIEW


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Problem Summary

- Disaster Scenario: first responders should have the ability to communicate and exchange information.
- Scarcity of available spectrum: is the greatest obstacle for wireless networks.
- Cognitive Radio: is a possible solution to the spectrum access obstacle.
- First Responders: can use idle portions of the spectrum to communicate with each other.
- Family Radio Service (FRS): band used to implement the cognitive radio network to transmit voice and data.
- Challenges:
  - Awareness: Nodes must be able to *sense* the channel for primary licensed users.
  - Coexistence: Share information with other cognitive nodes, communicate reliably and avoid legacy devices.

Contributions

- Designed and implemented: a cognitive radio modem on the Small Form Factor (SFF) Software Defined Radio (SDR) platform provided by Lyrtech and Texas Instruments (TI).
- Filterbanks: used for spectrum sensing.
  - Superior performance: in terms of the spectral dynamic range when compared with the FFT techniques.
  - High spectral dynamic range: enables reliable detection of low power users.

Side lobes of each sub-carrier made arbitrary small, hence reducing spectral leakage and improving the spectral dynamic range.

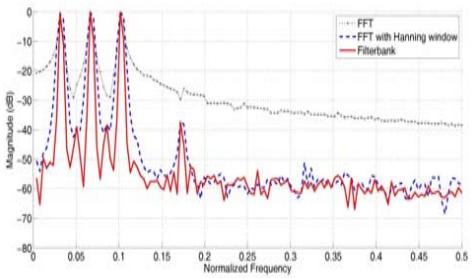
- Distributed sensing method: is used to ensure reliability.
- Fractionally spaced equalizer: is used for timing recovery and channel equalization..

Channel Sensing

- Secondary Users (SUs): need to dynamically and reliably determine the spectrum holes.
- Existing solutions:
  - FFT/OFDM: has been proposed as a spectrum sensing as well as communication method → suffers from large side lobes, i.e., significant spectrum leakage.
  - Multi-taper method: Computationally expensive

Our solution – uses *filterbanks* to sense the channel.

- Advantages:
  - Flexibility: to control the side lobes associated with each sub-carrier by adjusting the filter length and other design specifications.
  - Estimate signal spectrum: using the signal power output of the filterbank.



Transmitter

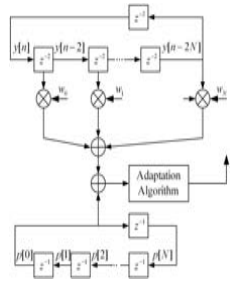
- Software defined modem provides 2 types of services:
  - 19.2 kbps computer-to-computer data stream.
  - 16 kbps Continuously Variable Slope Delta Modulation (CVSD) vocoded voice.
- Upconversion is done using a combination of:
  - Cascaded-Integrated-Comb (CIC) filters, and
  - A novel pulse-shaping filter (PSF) having the Nyquist-M property.

The combination of CIC and PSF filters achieves less passband ripple, more stopband attenuation and less ISI

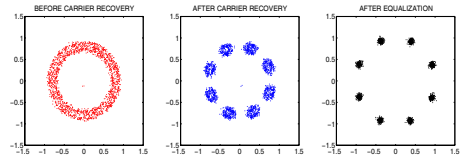
- Modulation: upconverted signal is modulated to IF for transmission over the channel.

Receiver

- Synchronization: is performed using a *cyclic preamble*.
- Cyclic preamble: generated using 3 BPSK modulated pseudo random sequences, each having length 64.
- Why do we use a cyclic preamble?
  - Repetition structure allows us to detect the packet
  - Estimate the timing and carrier offsets.
  - Enables equalizing the channel effects when coupled with a fractionally spaced cyclic equalizer.
  - Exhibits good performance and is easy to implement.



Half symbol-spaced cyclic equalizer.



MAC Layer

- **Key Features:**
  - Coexistence: is the primary goal.
  - FDD: SUs use frequency-division duplexing (FDD) to communicate with each other.
  - FDMA: The medium access method is frequency-division multiple access (FDMA).
- **Functions of the MAC Layer Control Channel:**
  - Control Channel: is used for coordinating sensing information, controlling leaf node communications, and other management tasks.
  - Channel Sensing: each leaf node stops transmitting and senses the entire channel periodically.
  - Transmitting Sensing Information: leaf nodes transmit to the base-station if the channel status changes.
  - Compiling Sensing Information: The base station receives and compiles the channel state data from all the leaf nodes and itself.
  - Broadcasting Sensing Information: The base station broadcasts the channel allocation table to all the leaf nodes.