Channel State Prediction in Cognitive Radio, Part I: Response Delays in Practical Hardware Platforms

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Outline

- Introduction
- Problem Formulation
- Measurement of Minimum Response Delay
- Conclusion
We have found that current hardware platforms for cognitive radio introduce time delays that actually undermine the accuracy of spectrum sensing.

In this paper, minimum response delays are experimentally quantified and reported based on two popular off-the-shelf hardware platforms, the universal software radio peripheral 2 (USRP2) and the small-form-factor software-defined-radio development platform (SFF SDR DP).
Cognitive Radio

- Cognitive radio is viewed as a novel approach for improving the utilization of the precious radio spectrum.
- Cognitive Radio – a technique of utilizing unused spectrums to communicate efficiently for secondary users without interfering primary users. It is able to sense, to learn, and to adapt.
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Time Slot

- Time slot is widely used in cognitive radio.
- Suppose each time slot contains two phases: spectrum sensing phase and communication phase.
  - Spectrum sensing phase – the duration for spectrum sensing
  - Communication phase – the duration for data transmission
Response Delay

- The response delay is a delay as a cognitive radio device receives a signal from a channel over the air for spectrum sensing, then transmits data to the air using the channel if the channel is believed to be available.
Minimum Response Delay

- The response delay can vary depending on how heavy the data processing is.
- The minimum response delay refers to the response delay with minimum processing work, i.e., loopback (just passing through data without actual processing), in the data processing module.
Minimum Response Delay

- It is wise to take into account the response delay in algorithm/protocol design and implementation for cognitive radio.

- How long is the minimum response delay?

- This question can be answered using measurements.
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Chosen Hardware Platforms

- Two existing commercial hardware platforms are chosen.
  - Universal software radio peripheral 2 (USRP2), a representative of host-based architecture.
  - Small-form-factor software-defined-radio development platform (SFF SDR DP), a representative of stand-alone architecture.
Equipment

- Arbitrary waveform generator (AWG)
  - Tektronix AWG7122B
  - Maximum sampling rate 12 GS/s
  - Two channels, 64 M samples per channel

- Digital phosphor oscilloscope (DPO)
  - Tektronix DPO72004
  - Maximum bandwidth 20 GHz
  - Maximum sampling rate 50 GS/s
  - Four channels, 250 M samples per channel
Setup of the Measurement for USRP2

- The AWG generates a sequence of gated sinusoidal waveforms of 250 MHz. The sinusoidal burst lasts 50 μs, and appears once every 2 seconds.

- The GNU Radio companion (GRC) runs on the host computer with Linux operating system. Using the GRC, a **USRP2 source block** and a **USRP2 sink block** are connected directly to form a loopback configuration.
Setup of the Measurement for SFF SDR DP

- The AWG generates a sequence of gated sinusoidal waveforms of 250 MHz. The sinusoidal burst lasts 500 μs, and appears once every 2 seconds.

- An example project called *SFF_SDR_RF_Loopback_ADACIII* coming with the Lyrtech software package runs on both the FPGA and the DSP on the digital processing module. The function *TASK_Transmit* for the DSP in the example project is slightly modified to simply loop back all the received data.
The Measured Minimum Response Delay of USRP2

- 500 consecutive readouts of the minimum response delay of USRP2 are recorded.

One readout

Distribution of the readouts

Random, spread from about 2 ms to 16 ms
The Measured Minimum Response Delay of SFF SDR DP

- 100 consecutive readouts of the minimum response delay of SFF SDR DP are recorded.

Constant, around 48 ms

One readout
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Conclusion

- The response delay issue has been identified.

- The minimum response delays of two popular hardware platforms have been measured.

- The measurement results can guide our future work in developing a cognitive radio network testbed.
In the following paper, an approach for single-user **channel state prediction** is proposed, to boost the accuracy of spectrum sensing and minimize the negative impact of the response delays caused by hardware platforms.
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