Abstract—Cognitive radio (CR) allows a pair of wireless communicating devices to intelligently adapt their transmission parameters based on the characteristics of the radio frequency (RF) environment, possibly using vacant portions of licensed frequency bands. A key step in this process is spectrum sensing, where the presence of primary users of the spectrum is detected by sending raw samples from the front-end to the host computer, a process that incurs significant processing delay. In this paper we introduce the Cognitive Radio Universal Software Hardware (CRUSH) platform that revisits the classical software defined radio (SDR) architecture by including a Xilinx ML605 FPGA board, thereby flexibly sharing the processing load with the host computer. CRUSH shifts the spectrum sensing overhead closer to the front-end. Our design results in orders of magnitude speedup and can flexibly connect up to three SDRs together, resulting in a powerful platform suitable for time-sensitive CR functions.

Index Terms—Cognitive Radio; Spectrum Sensing; FPGA; the existing USRP. The modified USRP firmware is designed to function with or without the presence of the ML605. The USRP firmware has been modified so that the data from the ADC lines are forked and sent over the interface between the USRP and the ML605 as well as to the host. The original Ethernet link is still intact so the USRP can be used as a standard radio in parallel with the accelerator.

Fig. 1: CRUSH Platform

Hardware Overview. The CRUSH system (Fig. 1) is comprised of three components (1) an Ettus Research USRP N210 software defined radio, (2) a Xilinx ML605 Development Board and (3) a custom interface board (CIB) to route signals between the USRP and the ML605. The interconnects between the boards are commercial off the shelf (COTS) cables. CRUSH is unique because it decouples the expensive, fast developing FPGA technology from the radio and configurable hardware; this allows either the FPGA or the radio to be updated independently.

A goal of the CRUSH platform is to minimize the impact on

Fig. 2: Spectrum Sensing Algorithm

Algorithm. CRUSH is currently being used as a spectrum sensing accelerator. The spectrum sensing algorithm is an FFT followed by a threshold operation (Fig. 2). The first step is receiving the RF data and digitizing it via the ADC. The result is the time domain digital representation of the RF data. Next we perform an FFT to convert the time domain data to the frequency domain. FFTs are referred to by their point size which represents how many output bins the FFT will produce; each bin represents the energy of a fraction of the total bandwidth. Once we have energy values for each bin, we apply a threshold. If the value of the bin exceeds this threshold, it is assigned 1. If it is below the threshold it is assigned 0.

Conclusion. CRUSH combines a powerful FPGA with a versatile RF front end. To enable this, we created a custom interface board that allowed high speed data transfer between two widely used COTS platforms. The signal processing is now closer to the receiver allowing for implementation of high speed, real time algorithms. This also decouples the FPGA computing resources from the SDR allowing for either to be updated independently. We implemented spectrum sensing as the first application on CRUSH. Spectrum sensing is now running at 100x the performance for FFT sizes of interest to cognitive radios. We have reduced the load on the host computer by running this algorithm in hardware and we have kept the system fully configurable. In the future we plan to integrate CRUSH into existing research on cognitive radio.