BUILDING A HIGH PERFORMANCE DSP FRAMEWORK FOR GPUS AND X86 HARDWARE: A LOOK AT THE DESIGN OF THE CHIME X-ENGINE AND BEAMFORMER

André Renard obo The CHIME Collaboration, *University of Toronto.*

We will present an open source C++14 framework used to build GPU based soft-real-time pipelines for digital signal processing, and discuss some of the performance issues encountered with software based DSPs and how to mitigate them. This framework, called kotekan, is currently used on the CHIME telescope and as a capture system for the ARO 46m and DRAO 26m telescopes. In CHIME, using a cluster of 256 servers with 1024 GPUs, the framework supports the processing of over 6.4 Tb/s of 4+4-bit radiometric data from the instrument's 2048 analog inputs over 400MHz of bandwidth. Supported GPU processing operations for CHIME include the full N^2 correlation, FFT power-beamforming, a 10-beam dynamically steerable voltage beamformer, and high cadence RFI excision. The framework has been designed to leverage GPU co-processors via the OpenCL and low-level HSA APIs. The talk will cover details of the network packet capture from the FPGAs over Ethernet with the DPDK library and userspace network drivers; in lab tests this has been shown to achieve packet capture rates of over 200Gb/s on dual-socket systems. Some of the other performance related topics covered will be: thread management, memory management best practices, ring buffer design, using cache-aware memory operations, using AVX intrinsics, and system performance debugging and monitoring. We will also cover some of the design choices in the kotekan framework, such as: pipeline composing via YAML files, HTTP based APIs for external control, APIs for exporting Prometheus metrics, and network transportable buffers. The talk will conclude with some thoughts on newly released and upcoming hardware, and the future of GPU based DSP systems.