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**A HIGH PERFORMANCE PARALLEL AND HETEROGENEOUS APPROACH TO NARROWBAND BEAMFORMING**

**ABSTRACT**

This paper describes a high performing, hybrid parallel, and heterogeneous algorithmic approach to narrowband Delay-Sum Beamforming (DSB) in the frequency domain using a Just-In-Time Asynchronous Data Method (JIT-ADM) parallel pattern. JIT-ADM is a novel asynchronous parallel programming pattern that unifies various levels of asynchronous concurrency available with distributed heterogeneous computing. The computational performance of this DSB algorithm was analyzed on a 50 node Cray XC30 with a single 10-core Intel Xeon E5-2670 v2 and NVIDIA Tesla K20X general purpose Graphics Processing Unit (GPU) on each node. The algorithm exhibits well behaved weak scalability with 92.7 percent parallel efficiency at 50 nodes compared to maximum performance observed. It is also shown that the algorithm efficiently utilizes a large portion of the available hardware. During beamforming the GPU is utilized at 51.8 percent of its maximum double precision floating point throughput whereas a comparable Central Processing Unit (CPU) version utilizes 60.0 percent of its maximum expected floating point throughput. Across the weak scalability study, utilizing GPUs for processing, a 2-5x performance gain is achieved compared to using CPUs. A brief derivation and validation of the implemented DSB is also presented.