A next-generation many-core processor with reliability, fault tolerance and adaptive power management features optimized for embedded and high performance computing applications

Simon McIntosh-Smith
ClearSpeed Technology plc
simon@clearspeed.com

Abstract

The CSX700 is a new many-core processor from ClearSpeed Technology. This paper will be its first public disclosure as an embedded processor. The CSX700 incorporates 192 optimized cores or "Processor Elements" (PEs), delivering 96 GFLOPS of IEEE754 single or double precision floating point, while consuming a maximum of just 10 watts.

Requirements for a next generation high-performance embedded processor

A next-generation high performance embedded processor needs to provide a number of key features:

- High absolute performance
- High energy efficiency
- Ease of use and full programmability
- Reliability and fault tolerance
- Flexible, adaptive power management

The CSX700 has been designed to meet these stringent requirements.

Reliability and fault tolerance features

The CSX700 includes Error Correcting Code (ECC) mechanisms for all on- and off-chip memories. It has been designed to run at very low power, with the resulting low running temperature of the chip yielding much greater long-term reliability. Each CSX700 is manufactured with "spare" PEs that can be kept in reserve in case of defects developing in the field in harsh environments.

Adaptive power management features

The CSX700 includes numerous adaptive power management features. The clock speed can be changed dynamically under software control in real-time while an application is in mid-flight, allowing the application to change the performance and power consumption of the device. The CSX700 includes integrated sensors for chip temperature and power consumption, allowing a CSX700-based system to dynamically manage a running application to stay within set power or temperature envelopes.

Figure 1: The CSX700 192-core embedded processor

Performance and power measurements

The performance and power consumption of the CSX700 has been measured across a range of benchmarks. We shall present these results in full in the paper. As an example, Figure 2 shows the power consumption of the CSX700 at a range of clock speeds when running a 1024x1024 2D single precision complex FFT, with all data starting and finishing in off-chip DRAM.

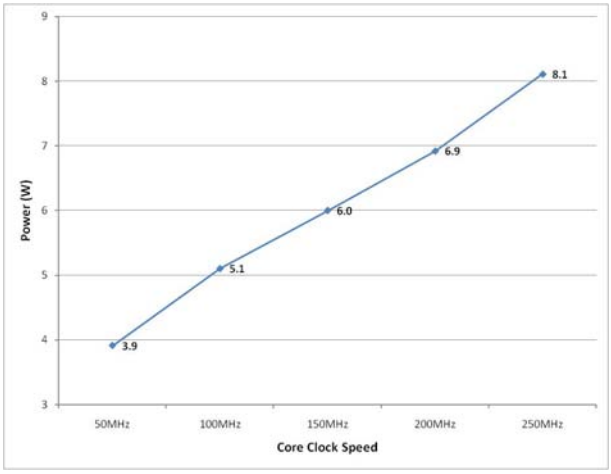

Figure 2: CSX700 2D FFT power consumption

In the full paper we will go into detail to show the effect of dynamic power management on FFT performance and power consumption.

Applicability in embedded computing

The CSX700's 96 GFLOPS at 10 watts is enabling a new class of high performance embedded processing solutions for applications in synthetic aperture radar, hyper spectral imaging, image processing, beam forming and holography.

Applicability in high performance computing

The CSX700's high performance and low power consumption is enabling a new class of accelerators for heavyweight computing problems. Figure 3 shows the ClearSpeed Accelerated Terascale System (CATS) which delivers 1 TFLOPS of single and double precision performance in a standard 1U rack mount form factor.

Figure 3 - The 1TFLOP in 1U "CATS"

Advanced software tools

It can be challenging to develop software for embedded many-core processors. In our paper we shall detail how ClearSpeed's architecture has been designed to make it easy to program. The architecture is complemented by ClearSpeed's advanced software development tools which further simplify the process of developing accelerated applications. These tools include a sophisticated profiler that can visualize real-time performance across a heterogeneous system of multiple different processors.

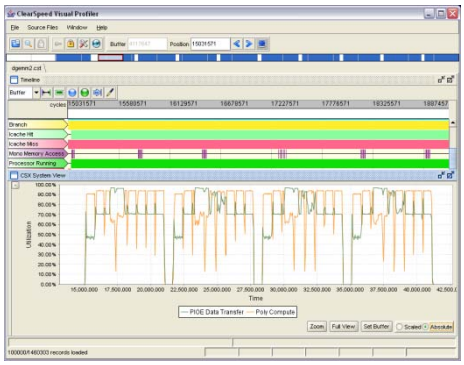

Figure 4 – Heterogeneous performance profiling

Summary

The CSX700 embedded processor is a breakthrough in terms of absolute performance, energy efficiency and ease of programming. Coupled with extensive reliability and redundancy features, the CSX700 is enabling embedded applications that were hitherto not possible.

If this paper is accepted at HPEC it will be the first public disclosure of the CSX700's embedded capabilities.