

# Characterization of FPGA-based High Performance Computers

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in partial fulfillment of the requirements for the degree of

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in  
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## **Virginia Tech ETD Fair Use Analysis Results**

***This is not a replacement for professional legal advice but an effort to assist you in making a sound decision.***

Name: Karl Savio Pimenta Pereira

Description of item under review for fair use: Diminishing Performance of CPUs and flattening clock frequencies.  
Source: H. Sutter, "The Free Lunch is Over: A Fundamental Turn Towards Concurrency in Software". Available online at <http://www.gotw.ca/publications/concurrency-ddj.htm>

Report generated on: 08-23-2011 at : 19:14:10

### **Based on the information you provided:**

#### **Factor 1**

Your consideration of the purpose and character of your use of the copyright work weighs: ***in favor of fair use***

#### **Factor 2**

Your consideration of the nature of the copyrighted work you used weighs: ***in favor of fair use***

#### **Factor 3**

Your consideration of the amount and substantiality of your use of the copyrighted work weighs: ***in favor of fair use***

#### **Factor 4**

Your consideration of the effect or potential effect on the market after your use of the copyrighted work weighs: ***in favor of fair use***

**Based on the information you provided, your use of the copyrighted work weighs: *in favor of fair use***

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Description of item under review for fair use: Technology gap between CPU performance and HPC application demands. Source: B. Mackin, "Accelerating High-Performance Computing With FPGAs", Altera, White Paper, 2007. Available online at <http://www.altera.com/literature/wp/wp-01029.pdf>.

Report generated on: 08-23-2011 at : 19:44:39

### **Based on the information you provided:**

#### **Factor 1**

Your consideration of the purpose and character of your use of the copyright work weighs: ***in favor of fair use***

#### **Factor 2**

Your consideration of the nature of the copyrighted work you used weighs: ***in favor of fair use***

#### **Factor 3**

Your consideration of the amount and substantiality of your use of the copyrighted work weighs: ***in favor of fair use***

#### **Factor 4**

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Name: Karl Savio Pimenta Pereira

Description of item under review for fair use: CPU Cluster Power Density Wall. Source: F. Pollack, "New Micro-architecture Challenges in the Coming Generations of CMOS Process Technologies", Intel. Available online at <http://research.ac.upc.edu/HPCseminar/SEM9900/Pollack1.pdf>

Report generated on: 08-23-2011 at : 19:51:07

### **Based on the information you provided:**

#### **Factor 1**

Your consideration of the purpose and character of your use of the copyright work weighs: ***in favor of fair use***

#### **Factor 2**

Your consideration of the nature of the copyrighted work you used weighs: ***in favor of fair use***

#### **Factor 3**

Your consideration of the amount and substantiality of your use of the copyrighted work weighs: ***in favor of fair use***

#### **Factor 4**

Your consideration of the effect or potential effect on the market after your use of the copyrighted work weighs: ***in favor of fair use***

**Based on the information you provided, your use of the copyrighted work weighs: *in favor of fair use***

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Description of item under review for fair use: Advancement of FPGA density, speed, and reduction in price over time.  
Source: P. Sundararajan, "High Performance Computing Using FPGAs" Technical Report, 2010. Available online at [http://www.xilinx.com/support/documentation/white\\_papers/wp375\\_HPC\\_Using\\_FPGAs.pdf](http://www.xilinx.com/support/documentation/white_papers/wp375_HPC_Using_FPGAs.pdf)

Report generated on: 08-29-2011 at : 03:58:23

### Based on the information you provided:

#### Factor 1

Your consideration of the purpose and character of your use of the copyright work weighs: *in favor of fair use*

#### Factor 2

Your consideration of the nature of the copyrighted work you used weighs: *in favor of fair use*

#### Factor 3

Your consideration of the amount and substantiality of your use of the copyrighted work weighs: *in favor of fair use*

#### Factor 4

Your consideration of the effect or potential effect on the market after your use of the copyrighted work weighs: *in favor of fair use*

**Based on the information you provided, your use of the copyrighted work weighs: *in favor of fair use***

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Description of item under review for fair use: The Splash system. Source: T. Waugh, "Field Programmable Gate Array Key to Reconfigurable Array Outperforming supercomputers", In the IEEE Proceedings of Custom Integrated Circuits Conference, 1991, May 1991, pp. 6.6/1-6.6/4.

Report generated on: 08-23-2011 at : 21:37:29

### **Based on the information you provided:**

#### **Factor 1**

Your consideration of the purpose and character of your use of the copyright work weighs: ***in favor of fair use***

#### **Factor 2**

Your consideration of the nature of the copyrighted work you used weighs: ***in favor of fair use***

#### **Factor 3**

Your consideration of the amount and substantiality of your use of the copyrighted work weighs: ***in favor of fair use***

#### **Factor 4**

Your consideration of the effect or potential effect on the market after your use of the copyrighted work weighs: ***in favor of fair use***

**Based on the information you provided, your use of the copyrighted work weighs: *in favor of fair use***

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Description of item under review for fair use: FPGA HPC use model. Source: P. Sundararajan, "High Performance Computing Using FPGAs" Technical Report, 2010. Available online at [http://www.xilinx.com/support/documentation/white\\_papers/wp375\\_HPC\\_Using\\_FPGAs.pdf](http://www.xilinx.com/support/documentation/white_papers/wp375_HPC_Using_FPGAs.pdf).

Report generated on: 08-29-2011 at : 04:04:53

### **Based on the information you provided:**

#### **Factor 1**

Your consideration of the purpose and character of your use of the copyright work weighs: *in favor of fair use*

#### **Factor 2**

Your consideration of the nature of the copyrighted work you used weighs: *in favor of fair use*

#### **Factor 3**

Your consideration of the amount and substantiality of your use of the copyrighted work weighs: *in favor of fair use*

#### **Factor 4**

Your consideration of the effect or potential effect on the market after your use of the copyrighted work weighs: *in favor of fair use*

**Based on the information you provided, your use of the copyrighted work weighs: *in favor of fair use***

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Description of item under review for fair use: Convey HC-1's 2U enclosure. Source: T. M. Brewer, "Instruction Set Innovations for Convey's HC-1 Computer", Presentation at Hot Chips Conference, 2009. Available online at [http://www.hotchips.org/archives/hc21/3\\_tues/HC21.25.500.ComputingAccelerators-Epub/HC21.25.526.Brewer-Convey-HC1-Instruction-Set.pdf](http://www.hotchips.org/archives/hc21/3_tues/HC21.25.500.ComputingAccelerators-Epub/HC21.25.526.Brewer-Convey-HC1-Instruction-Set.pdf).

Report generated on: 08-23-2011 at : 21:48:38

### **Based on the information you provided:**

#### **Factor 1**

Your consideration of the purpose and character of your use of the copyright work weighs: *in favor of fair use*

#### **Factor 2**

Your consideration of the nature of the copyrighted work you used weighs: *in favor of fair use*

#### **Factor 3**

Your consideration of the amount and substantiality of your use of the copyrighted work weighs: *in favor of fair use*

#### **Factor 4**

Your consideration of the effect or potential effect on the market after your use of the copyrighted work weighs: *in favor of fair use*

**Based on the information you provided, your use of the copyrighted work weighs: *in favor of fair use***

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Description of item under review for fair use: Convey HC-1 system block diagram. Source: Convey HC-1 Personality Development Kit Reference Manual, v 4.1, Convey Corporation, 2010.

Report generated on: 08-23-2011 at : 21:52:30

### **Based on the information you provided:**

#### **Factor 1**

Your consideration of the purpose and character of your use of the copyright work weighs: ***in favor of fair use***

#### **Factor 2**

Your consideration of the nature of the copyrighted work you used weighs: ***in favor of fair use***

#### **Factor 3**

Your consideration of the amount and substantiality of your use of the copyrighted work weighs: ***in favor of fair use***

#### **Factor 4**

Your consideration of the effect or potential effect on the market after your use of the copyrighted work weighs: ***in favor of fair use***

**Based on the information you provided, your use of the copyrighted work weighs: *in favor of fair use***

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Name: Karl Savio Pimenta Pereira

Description of item under review for fair use: Pico M-503 Modules and EX-500 backplane. Source: M-503 Hardware Technical Manual, Rev B, Pico Computing Inc., 150 Nickerson Street Suite, 311, Seattle, WA 98109.

Report generated on: 08-23-2011 at : 21:55:34

### **Based on the information you provided:**

#### **Factor 1**

Your consideration of the purpose and character of your use of the copyright work weighs: ***in favor of fair use***

#### **Factor 2**

Your consideration of the nature of the copyrighted work you used weighs: ***in favor of fair use***

#### **Factor 3**

Your consideration of the amount and substantiality of your use of the copyrighted work weighs: ***in favor of fair use***

#### **Factor 4**

Your consideration of the effect or potential effect on the market after your use of the copyrighted work weighs: ***in favor of fair use***

**Based on the information you provided, your use of the copyrighted work weighs: *in favor of fair use***

**Draft 09/01/2009**

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Description of item under review for fair use: Overview of NVIDIA GPU architectures. Source: M. Daga, "Architecture-Aware Mapping and Optimization on Heterogeneous Computing Systems", Master's thesis, Virginia Tech, 2011.

Report generated on: 08-23-2011 at : 22:00:22

### **Based on the information you provided:**

#### **Factor 1**

Your consideration of the purpose and character of your use of the copyright work weighs: *in favor of fair use*

#### **Factor 2**

Your consideration of the nature of the copyrighted work you used weighs: *in favor of fair use*

#### **Factor 3**

Your consideration of the amount and substantiality of your use of the copyrighted work weighs: *in favor of fair use*

#### **Factor 4**

Your consideration of the effect or potential effect on the market after your use of the copyrighted work weighs: *in favor of fair use*

**Based on the information you provided, your use of the copyrighted work weighs: *in favor of fair use***

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Description of item under review for fair use: Dwarf presence in myriad applications and their performance bounds.  
Source: K. Asanovic et al., "A View of The Parallel Computing Landscape", In the Communications of the ACM, vol. 52, pp. 5667, October 2009

Report generated on: 08-23-2011 at : 22:14:01

### **Based on the information you provided:**

#### **Factor 1**

Your consideration of the purpose and character of your use of the copyright work weighs: ***in favor of fair use***

#### **Factor 2**

Your consideration of the nature of the copyrighted work you used weighs: ***in favor of fair use***

#### **Factor 3**

Your consideration of the amount and substantiality of your use of the copyrighted work weighs: ***in favor of fair use***

#### **Factor 4**

Your consideration of the effect or potential effect on the market after your use of the copyrighted work weighs: ***in favor of fair use***

**Based on the information you provided, your use of the copyrighted work weighs: *in favor of fair use***

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Description of item under review for fair use: The OpenCL architecture standard. Source: B. Alun-Jones, "A Quick Introduction to OpenCL". Available online:<http://www.mat.ucsb.edu/594cm/2010/benalunjones-rp1/index.html>

Report generated on: 08-23-2011 at : 22:26:39

### **Based on the information you provided:**

#### **Factor 1**

Your consideration of the purpose and character of your use of the copyright work weighs: *in favor of fair use*

#### **Factor 2**

Your consideration of the nature of the copyrighted work you used weighs: *in favor of fair use*

#### **Factor 3**

Your consideration of the amount and substantiality of your use of the copyrighted work weighs: *in favor of fair use*

#### **Factor 4**

Your consideration of the effect or potential effect on the market after your use of the copyrighted work weighs: *in favor of fair use*

**Based on the information you provided, your use of the copyrighted work weighs: *in favor of fair use***

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Description of item under review for fair use: Visual output of GEM. Shows the outer surface of a virus capsid color-coded according to the electrostatic potential computed. Source: J. C. Gordon, A. T. Fenley, and A. Onufriev, "An Analytical Approach to Computing Biomolecular Electrostatic Potential. II. Validation and Applications", The Journal of Chemical Physics, vol. 129, no. 7, pp. 075 102, 2008

Report generated on: 08-23-2011 at : 22:38:59

### **Based on the information you provided:**

#### **Factor 1**

Your consideration of the purpose and character of your use of the copyright work weighs: ***in favor of fair use***

#### **Factor 2**

Your consideration of the nature of the copyrighted work you used weighs: ***in favor of fair use***

#### **Factor 3**

Your consideration of the amount and substantiality of your use of the copyrighted work weighs: ***in favor of fair use***

#### **Factor 4**

Your consideration of the effect or potential effect on the market after your use of the copyrighted work weighs: ***against fair use***

**Based on the information you provided, your use of the copyrighted work weighs: *in favor of fair use***