# Status Report of the OpenFPGA Initiative: Early Efforts in FPGA Application Standardization

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***ABSTRACT:*** *The OpenFPGA initiative began officially in early 2005. From early formative discussions, the effort has matured to become a community resource to foster and advance the adoption of FPGA technology for high-level applications. Participation includes vendors, application providers, and application users across academic, commercial and governmental organizations. With widespread and international participation by hundreds of participants, an active discussion list on FPGA related topics, and emerging working groups, the OpenFPGA effort is building a strong foundation for broad incorporation of FPGA accelerated high-level applications. This presentation will cover insight from early discussions, current organizational overview, future directions towards standardization and information for becoming part of the OpenFPGA effort.*

**KEYWORDS: OpenFPGA, FPGA, Standards, Common API**

## Background

Programming of FPGA (Field Programmable Gate Array) devices is undergoing a significant transformation. Driven by the introduction of FPGA technology into a high-level software application development environment, several new approaches are emerging as viable methods for utilizing this exciting new technology to accelerate applications.

The interest in utilizing FPGA technology for high-level applications has been driven by a number of factors, ultimately related to power. For approximately the past ten years, performance improvements have been tracking with increased CPU clock rates, doubling roughly every 18 months from 60 MHz (1994) to over 3 GHz for the latest processors, a factor of fifty-fold. However, as the processors have become increasingly capable, power management has become a critical issue, now limiting the continued increase in performance associated with higher clock rates. Consequently, applications are requiring increased use of parallel computing technologies (such as multi-core CPUs and FPGAs) to achieve continued increases in application performance.

At the same time, the quantity of data under management in computing centers is dramatically increasing. A confluence of technical advances in higher storage densities and improved affordability and business interest in management of intellectual property and regulatory compliance (e.g. Sarbanes-Oxley and HIPAA) have motivated businesses to increase demand for data storage and analysis capabilities. In the research community, high-performance instruments and scientific applications are generating staggering amounts of new information also destined for subsequent analysis.

The cumulative effect of increased demands for power and space to support

increased processing power and data storage has dramatically raised the importance of power and space efficient computing solutions.

At the same time, the techniques for increased circuit density that have enabled today's high-performance CPUs have also enabled gate counts on FPGAs to increase to levels where enterprise applications can benefit. While FPGA technology has been around for nearly twenty years, it has taken these latest developments to open the door for FPGA technology in high-level applications and created the demand for improved methods for application development.

Active FPGA and reconfigurable computing research is occurring across the globe. Academic research developments are regularly delivering new approaches and insight for translating algorithms into use on FPGA systems. While application successes are emerging, much of the work still requires design and specification of the FPGA execution layout in VHDL, a language better suited for digital design, but not software development. As a result, development time required for applications incorporating FPGA technology have followed a digital design timeframe, frequently requiring months to define, design, develop and deliver an executable image. Both academic and commercial efforts have appeared to bridge between software engineering and digital logic design.

At the present time, a number of independent software vendors (ISVs) have brought new FPGA development tools to market, each advancing distinct solutions for application development on FPGAs. Companies such as Nallatech, Mitrionics, DSPLogic, Celoxica, ImpulseC, SRC, and more all have such products available, but. all solutions are different. Compounding matters, multiple tools are may be required (frequently from different vendors) to deliver a complete application development environment.

The extremely diverse development environment, the variety of distinct solutions and the relative infancy for high-level application development involving FPGAs (both commercial and academic) has created an environment where portability and interoperability do not yet exist. The OpenFPGA initiative has been undertaken to accelerate efforts to culminate in application portability, component interoperability, and ultimately improved viability of high-performance applications involving FPGA and reconfigurable technology.

**About OpenFPGA**

OpenFPGA began as a response to address several challenges. The efforts of OpenFPGA are directed to:

***Solve Fragmentation*** – by encouraging communication among independent efforts underway in the industry.

***Address Common Challenges*** – by developing a mutual list of priorities to resolve including: reducing the cost of development tools, shortening development times, improving portability and easing market entry of FPGA application solutions.

***Improve Common Practices*** – accelerate the use of FPGAs in high-level applications through use of common models and syntax (much as OpenMP and MPI have proliferated the use of

shared memory and distributed memory programming, respectively.)

***Influence Priorities for Future Architectures*** – by developing general consensus for features required in future FPGA and system designs for successfully performing FPGA applications.

Ultimately the efforts will result in ***lowering the risk of adoption of FPGA technology by the high-performance and enterprise application development and end-user communities.***

The vision of OpenFPGA has three key elements to guide the initiative. The first element is to create a future where advances in reconfigurable computing can be easily and eagerly adopted. The second, to establish interoperability practices among components to preserve invested intellectual effort in application development and improve portability over time. The final emphasis of OpenFPGA is to serve as a conduit to funnel advances in reconfigurable computing research into general use in production computing.

These three guiding elements provide the underpinnings for the organizational mission:

*"The mission of OpenFPGA is to promote the use of Field Programmable Gate Arrays in high level and enterprise applications by collaboratively defining, developing and sharing critical information, technologies and best practices."*

The mission is presently underway with concentrated efforts in six key areas – innovation and evaluation, standardization, education, promotion, communication and collaboration, and participation.

**History and Status of OpenFPGA**

The OpenFPGA initiative commenced late in 2004, following an OSC (Ohio Supercomputer Center) hosted reconfigurable computing workshop in Springfield, Ohio. The initiative was formally announced in February 2005 in Manchester, England at their first technical symposium for reconfigurable computing. The announcement was made shortly after the formation of an organizational steering group. The international steering group spanned commercial, academic, government, application developers, hardware vendors, and production interests in the use of high-performance reconfigurable computing. Steering group organizations contributing during the formative period include: Cray Inc., George Washington University, GE Global Research, Koan Corporation, Mitrionics Inc, Nallatech Inc., NCI-ABCC, NCSA, NIST, Oak Ridge National Laboratory, OSC, Riken, Sandia National Laboratory, SGI Inc., SRC Computers Inc., Starbridge Systems Inc., University of Cincinnati, University of Manchester (England), University of South Carolina, University of Toledo, and Zuse Institute Berlin.

Since first convening, the OpenFPGA steering group has conducted biweekly conference calls since March 2005, calls that have proven very effective in improving communication among several FPGA research and development efforts. OpenFPGA has also conducted several Birds-of-a-Feather (BoF) sessions, further broadening the extent of communication. The first BoF, held at MAPLD in September 2005, proved

very constructive in defining future working groups. Additional BoFs have been held at Supercomputing 2005 and most recently at CUG 2006.

Interest in the initiative has grown steadily since the original announcement in 2005. As seen in Figure 1, the size of the community (as measured by cumulative website registrations) continues to grow at a steady rate, surpassing 300 cumulative registrations within the first year.

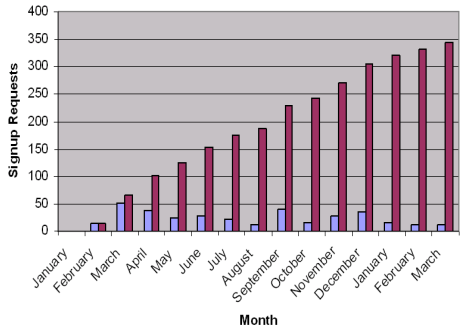


**Figure 1. OpenFPGA participation growth since inception in February 2005. Red bars are cumulative website registrations. Light blue bars are monthly signup requests.**

The information provided by individual website registrations provides intriguing insights into the organizations interested in FPGAs (See Figure 2). Approximately forty per cent of the organizations are research and development. Slightly over fifteen per cent are educational institutions and another fifteen per cent are hardware manufacturers. The remaining represent a diverse set of application areas including aerospace, government (including military), financial, energy, agriculture, pharmaceutical and retail/wholesale.

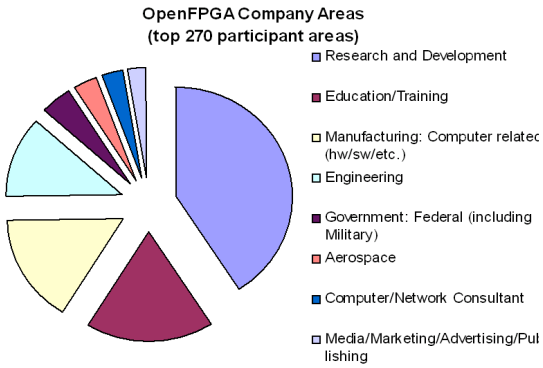


**Figure 2. OpenFPGA participant organization profile. The top 270 participant areas are listed.**

The diversity of organizations contributes to the diversity of individual interests in applications of FPGA technology. The interests range from the purely technical (programming FPGA chips, low power design, and clusters of FPGAs), to the more general (software tools, algorithms, and benchmarks) while also including the very application specific areas of signal image processing, data mining, cellular automata, biological modeling, bioinformatics, numerical simulation and automotive.

A breakdown by country shows interest leading in the United States and UK, with additional interest scattered throughout Europe and Asia. Figure 3 provides a graphical breakdown of the participation in OpenFPGA worldwide.

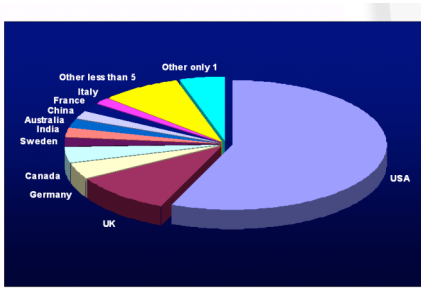


**Figure 3. World-wide participation in OpenFPGA based on registered country. Several countries are not listed where the number of participants is less than five.**

## OpenFPGA Organization

As mentioned earlier, OpenFPGA has established working groups in critical areas as a result of preliminary efforts to move towards a common standard for FPGA application development. A main thrust of OpenFPGA is to insure coordination and communication as simultaneous advances are made in key areas. The working groups cover two primary categories: applications and technical. The applications working groups focus on elements to be addressed to derive value from reconfigurable technology and include the following:

***Application Requirements*** – to characterize application needs present and future

***Applications Libraries*** – to deliver usable FPGA enhanced libraries for specific application areas

***Benchmarking*** – to define metrics to compare FPGA application performance

The technical working groups delineate different levels of the application software stack, specifically:

***High-level Languages*** – to define common practices and approaches for specifying algorithms for execution on reconfigurable hardware

***General API*** – to define a common API for interacting with the FPGA unit as a system component

***Core Libraries*** – to define practices and standards to improve interoperability among low-level functional cores.

The working groups will be joined in the near future by two additional key stakeholders. An Industry Advisory Council will be formed which will strengthen the representation of the ultimate end-user where the value of FPGA applications is paramount. Concurrently, a Standards Review Board is planned to provide appropriate vetting and confirmation of standards proposed across multiple levels of FPGA applications.

In support of the activities, OpenFPGA maintains a website, www.openfpga.org, and communication tools including a collaborative wiki and members email list for discussing key topics, sharing updates and seeking assistance or insight from the broader community. Specific mailing lists are maintained to support communication among working group members.

## OpenFPGA: Community Value

The lasting impact of the OpenFPGA effort is the obvious improved portability and reduced development and support cost for applications involving reconfigurable computing technologies. Implemented as a standards definition process, the adoption of common approaches by large segments of the industry space will have a dramatic impact. Indeed, the trend is good in this direction as vendors are now beginning

to share once sensitive details about their individual approaches to programming FPGAs on their computing systems. The very successful efforts to standardize symmetric multi-processing with OpenMP and distributed memory parallel processing with MPI bode well for future success in defining common models and syntax for FPGA applications development. This same success will also rapidly move to standards for interoperability among both FPGA application components and development tools.

By far the current most visible effect that OpenFPGA is having is enhanced communication among the community. Prior to the OpenFPGA effort, communication about FPGA applications technology was isolated and intermittent. The bi-weekly OpenFPGA conference calls (now continued as Technology Roundtable discussions) continue to prove useful for all involved as the industry undergoes rapid change. While certainly not solely responsible for the increased visibility and interest in FPGA technology for high level and enterprise applications, the combination of BoFs, sponsored workshops, website and regular conference calls has established a visible critical mass of reconfigurable computing stakeholders. This critical mass of stakeholders (which includes industry leaders worldwide) and the collaborative emphasis on shared solutions offers the OpenFPGA community a significant voice in setting the direction for future reconfigurable computing architectures.

**Summary**

OpenFPGA is by far the largest international collaborative community working to promote and deliver common solutions involving reconfigurable computing technology. The effort has grown in size to nearly 400 participants worldwide in slightly more than a year's time. Working groups have been established and are making progress in their technical pursuits. As the initial but crucial organizational efforts are completed, the focus of the organization continues to shift to delivering on the sustaining vision: to create a truly efficient and vibrant FPGA application industry.

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