Multi-Core Utilization without Threading:

EnFuzion Lets Single-Threaded Applications Execute in Parallel, Without Re-Writing

WHO

Axceleon is a leader in high-performance distributed computing software.

WHAT

EnFuzion is a field-proven solution that enables single-threaded applications to fully utilize multi-core processors without the need to thread these applications.

WHY

EnFuzion utilizes process-level data parallelism to enable single-threaded applications to run on multi-core processors. Without a need for threading and rewriting the applications, EnFuzion enables ISVs to go to market now with solutions that take full advantage of the performance from Intel multi-core processors.

WHY INTEL

Intel is revolutionizing the industry by introducing multi-core processors into laptop, desktop, and server platforms and delivering new levels of performance to applications that are multi-core-ready.

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MULTI-CORE PROCESSING: OPPORTUNITY AND CHALLENGE

The advent of multi-core processing represents a revolutionary opportunity for ISVs and enterprises. By placing more than one execution core in a single processor package, these chips bring unprecedented levels of performance to both server and client machines. Intel has announced plans to introduce multi-core platforms into all its major processor lines by the end of 2006. Taking full advantage of multi-core processors requires some means of dividing work among the cores. Threading, the most common means of accomplishing this, requires a great deal of time and effort; EnFuzion, a solution made by Axceleon Inc., provides a simpler alternative for many applications.

EnFuzion Allocates Work among Cores without Need for Threading

On its own, a single-threaded application can generally utilize only one execution core on a multi-core processor. In order to take advantage of multiple cores, ISVs often undertake the process of introducing multi-threading into their code, which requires extensive rewriting and is associated with substantial added effort and expense. Moreover, threading applications is a complex undertaking, and unsuccessful threading projects can actually reduce performance, rather than improving it. Such cases of reduced performance are not even discernable until substantial investment has been made.

EnFuzion provides an alternative to threading that does not require separate development effort to support multi-core processing. Therefore, developers can avoid common pitfalls associated with threading code, such as race conditions, deadlocks, and thread stalls, greatly simplifying the effort to get the most performance out of parallel computing resources.

EnFuzion exploits the data parallelism that exists in many applications to distribute computation among all the execution cores in a multi-core processor. This process-level data paralelism allows an application, unaltered, to effectively utilize available processing power to achieve higher performance.

Figure 1 shows an example of how EnFuzion enables a single-threaded application to fully utilize a dual-core processor with Hyper-Threading Technology. An instance of the single-threaded program, completely unaltered, runs on each of the four logical processors. EnFuzion distributes input data to each logical processor at run-time to compute results in parallel. Results are collected and reassembled by EnFuzion after the computation is done. By utilizing all computing resources, EnFuzion enables the same program to produce an equivalent amount of data in less time, producing a significant performance gain.

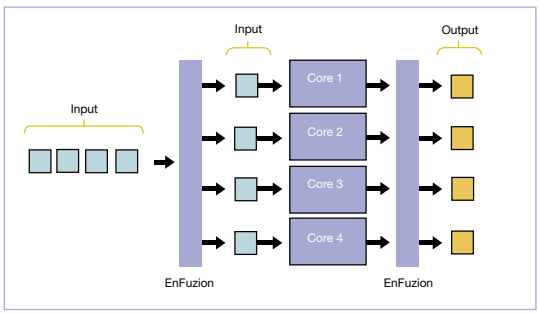

Figure 1. EnFuzion divides work from unthreaded application among execution cores.

"ISVs need to have a way to utilize multi-core and Hyper-Threading Technology now, without rewriting their applications. EnFuzion is the way."

Rok Sosic, CTO,
Axceleon, Inc.

Multi-Core Execution Utilizes All Available Resources

Because of the ability of the EnFuzion platform to allocate workload among all available execution cores, an application is able to make better use of the processor resources available to it. For example, the dual-core Intel® Pentium® Processor Extreme Edition 840 supports Hyper-Threading Technology, providing hardware support for four logical processors, with each core running at 3.20 GHz. A single-threaded application running on its own on this processor would have a maximum processor utilization of 25%, since three of the four logical processors would be unutilized.

The same system running with the EnFuzion solution, on the other hand, could run at 100% processor utilization on all four logical processors, as represented in Figure 2.

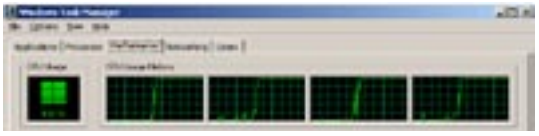

Figure 2. EnFuzion enables many single-threaded applications to run successfully at 100% CPU usage on multiple logical processors.

The key value proposition associated with the solution is that obtaining this utilization does not require the application to be rewritten.

Implementing Process Level Data Parallelism on Multi-core Processors

Many commercial products and in-house applications share a common attribute – they produce one output data set for each of multiple input data sets. Such applications are often data-parallel, meaning that input data sets can be processed independently from each other. Examples of data-parallel applications are abundant in both commercial and home-grown applications. A large proportion of mathematical, statistical, engineering computation, and analytical software falls into this category. Other examples include many types of simulation, digital-rendering, life sciences, and financial software.

Most of these applications are single-threaded, and they are not designed to take advantage of their inherent data parallelism. Input data sets are processed sequentially, even when executed on a multi-core processor. Data parallelism can be easily exploited in single-threaded applications by running several application instances concurrently. This data parallelism at a process level is able to fully utilize all logical processors of a multi-core processor.

EnFuzion provides a framework to run data-parallel applications on multi-core platforms by distributing the computation among all the cores. Since the parallelizing happens at the process/data level, there is no need to change the applications at all; a single-threaded application can run as-is, on every core. EnFuzion provides a mechanism external to the application to distribute input data at run-time. Input processing is scheduled according to available resources/cores, so that the computation happens in parallel, and maximum utilization of resources is achieved. EnFuzion also manages execution, collects results, and cleans up resources after the computation is done.

Figure 3 shows a single-threaded program running on a multi-core processor. Unthreaded and unaltered, it is only able to utilize one of the four available logical processors, or a maximum 25% overall utilization. In Figure 4, the same program is multi-core enabled with EnFuzion. The unaltered program now executes on all four logical processors, providing up to 100% utilization of hardware resources. The same code is able to produce more results per unit of time, providing a significant performance boost.

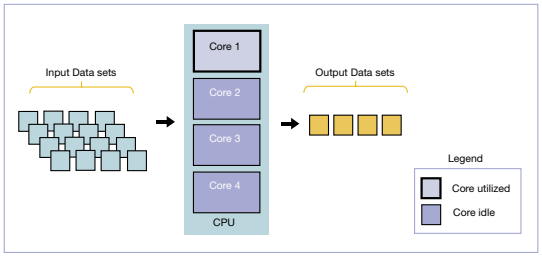

Figure 3. Single-threaded applications, on their own, can only utilize one of the available logical processors on a system, leaving the others idle.

Scalable Solution for Multi-core Processors, Clusters, and Grids

The method that EnFuzion employs to enable single threaded applications to run on multi-core processors extends seamlessly to compute clusters and grids. By leveraging process-level data parallelism, EnFuzion provides a unified method to allow single-threaded applications to scale from a single CPU to multi-core processors and to compute clusters and grids. Using EnFuzion, data-parallel applications can deliver winning performance today and also utilize next-generation Intel architecture, providing headroom and scalability for the future.

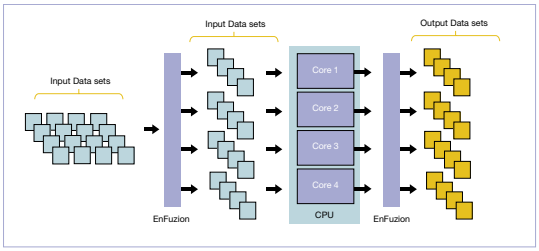

Figure 4. EnFuzion manages data streams among multiple execution cores to produce more results per unit of time.

EnFuzion Speeds Time to Market for ISVs

EnFuzion is ideally suited for use by ISVs that currently produce single-threaded data-parallel applications for the mathematical, statistical, engineering analysis and visualization, computer animation, financial simulation, and life sciences fields. EnFuzion is also an excellent solution for home-grown applications used by all kinds of enterprises.

Removing the need to thread their applications, ISVs can utilize EnFuzion to go to the market immediately with multi-core-enabled products. These products can take full advantage of the new parallel hardware architecture and produce a performance boost for users, without requiring additional development effort.

Most ISVs have invested substantial resources to develop and optimize their products over time. Threading these programs to utilize multi-core hardware requires some degree of initial de-stabilization. Often, first efforts in threading applications come up short of their performance targets. Since EnFuzion requires no change for single-threaded, data-parallel applications to run on multi-core processors, ISVs not only gain a time-to-market advantage, but they also continue to benefit from all the performance optimizations they have invested in their original products.

Multiple Implementation Options Enhance Flexibility

Many options exist for ISVs to incorporate EnFuzion as a part of their multi-core enabled products, ranging from no integration, to loosely coupled script-based integration, to tight integration with those products. EnFuzion can be used alongside of commercial applications with its own user interface exposed to the users, or it can be completely embedded and hidden within the ISV products. This flexibility enables ISVs to take control over the user experience and to decide how best to integrate the EnFuzion functionality.

For users of commercial applications, as well as data centers where server-based applications are in use, EnFuzion offers IT teams a simple way to multi-core-enable both purchased applications and software that was created in-house. In either case, internal IT teams generally do not have access to the source code. In such cases, EnFuzion enables these enterprises to take advantage of multi-core and multi-processor hardware, as well as Hyper-Threading Technology, without requiring changes to the application code.

Nearly a Decade of Experience Supports a Brand New Technology

Since its first release in 1996, EnFuzion has been adopted in many mission-critical and high-performance applications. First deployed as a distributed computing solution for clusters, EnFuzion delivered scalability, high job throughput, low latency, and reliability to compute-intensive applications in financial, engineering, animation rendering, and life sciences fields.

EnFuzion scored several industry firsts on Intel platforms. While doing research on the technology related to EnFuzion, the original development team built, quite possibly, the industry's first Intel architecture-based Linux* Beowulf cluster in 1993, even before the name was coined. In 1999, EnFuzion became the first technology of its kind to be deployed on Wall Street, to enable a mission-critical financial application to run on a large cluster with hundreds of Intel processors. In 2000, EnFuzion was used to build the first operating system for the Intel Itanium® processor. EnFuzion was instrumental in automating the build process and reducing the time required to complete the very first Linux port on the Itanium processor.

As a distributed computing solution for clusters, EnFuzion served as an enabler for commercial and home-grown applications to run on clusters, without any modification to the applications. The same technology developed and improved over the past decade is now applied to utilizing the new Intel multi-core processors and Hyper-Threading Technology.

Today, EnFuzion is a mature and field-proven offering that supports multi-core processors and Hyper-Threading Technology in the same way that it has supported compute clusters for many years. EnFuzion continues to enable users to achieve maximum utilization of Intel architecture-based hardware, without the need to reinvent their applications.

"Our value proposition has always been to take customer applications and run them on clusters without changing them. In this sense, a multi-core processor is really just a cluster on a chip."

Rok Sosic, CTO,
Axceleon, Inc.

CONCLUSION

The advent of multi-core processor technology promises unprecedented performance improvements, while ISVs and corporate IT professionals face the challenge to retool their applications in order to take advantage of these new platforms. While the techniques for creating multi-threaded versions of applications are relatively well-known, threading projects tend to be complex, and obtaining optimal results can be a challenge. EnFuzion provides an alternative to threading those applications. By exploiting process-level data parallelism, EnFuzion enables single-threaded applications to fully utilize all execution cores of a multi-core processor and achieve an application performance gain. EnFuzion enables faster time-to-market and lower development costs to take advantage of the emerging generation of multi-core processors from Intel.

Intel has announced more than 15 projects to introduce multi-core computing into all of its major product lines by the end of 2006. As Intel introduces this next generation of multi-core processors, the opportunity for ISVs and enterprises that have positioned themselves to take advantage of the multi-core revolution will achieve higher performance and a potential competitive advantage.

Intel Technology

Intel® Pentium® D processor, formerly code-named “Smithfield”

Intel® Pentium® Processor Extreme Edition 840

Intel® multi-core processingy

TAKING ACTION

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