Foreword

In 2001, I spoke to the trend toward increasing heat created by microprocessors, and I said that in the years ahead it would not be "business as usual" when fabricating these devices.

With research and innovation in materials science, process technology, and microarchitectures, we at Intel have attacked the thermal problem with significant success. What resulted was a *right-hand turn* to multi-core processing as we entered a new era of Moore's law.

The first era was dominated by the need to understand the materials, physics, and chemistry to make Moore's law work. The second era was about scale and manufacturing efficiency to deliver products in high volume. The right-hand turn has taken us to the new third era, which is all about energy efficient performance.

IT professionals running large data centers have been given a ferocious foursome of challenges that have converged to provide an intense focus on data center efficiency. Rising energy costs are increasing the total cost of ownership (TCO) of the data center center. Simultaneously, the economic environment is not only resisting increments but demanding lower TCO in short order.

Moreover, higher density servers driven by multi-core processors and dense form factors such as server blades are rapidly increasing the rapidly increasing power density in the data center. Finally, eco-technology requirements are now socially expected; they are not just regulatory requirements. This combination of challenges has quickly created a

demand for improvements in data center power efficiency. We now need the equivalent right-hand turn at the data center level.

Real-world technical problems are rarely solved by improvements on single dimension. This is especially true when addressing the challenges of minimizing power consumption in a data center. Lauri Minas and Brad Ellison have identified a multitude of loads that contribute to power consumption and have recommended ways to reduce power consumption for each of the loads.

As Minas and Ellison report, Intel continues to make improvements at the processor level, and the performance per Watt ratio is responding favorably. They also point out that, while servers consume the most energy, other systems draw power as well. A thorough analysis of power consumption includes storage systems and network switches.

Perhaps the richest vein in this gold mine of a book is the authors' analysis of emergent power consumption issues at the data center level. With increasing compute density, both power distribution and cooling quickly dominate floor space as limiting factors to the overall capacity of a center.

Minas and Ellison report Intel's modeling of thermal behavior to better understand how cool air should be routed through racks of servers. They provide the necessary metrics to measure power consumption and track year-over-year improvements.

I recommend this book to IT professionals who want a comprehensive treatment of the many dimensions of power usage. I am pleased to see these Intel engineers sharing our experience with our community of customers.

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