

Adaptive Techniques for Dynamic Processor Optimization

Theory and Practice

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Theory and Practice

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Preface

The integrated circuit has evolved tremendously in recent years as Moore's Law has enabled exponentially more devices and functionality to be packed onto a single piece of silicon. In some ways however, these highly integrated circuits, of which microprocessors are the flagship example, have become victims of their own success. Despite dramatic reductions in the switching energy of the transistors, these reductions have kept pace neither with the increased integration levels nor with the higher switching frequencies. In addition, the atomic dimensions being utilized by these highly integrated processors have given rise to much higher levels of random and systematic variation which undercut the gains from process scaling that would otherwise be realized. So these factors—the increasing impact of variation and the struggle to control power consumption—have given rise to a tremendous amount of innovation in the area of adaptive techniques for dynamic processor optimization.

The fundamental premise behind adaptive processor design is the recognition that variations in manufacturing and environment cause a statically configured operating point to be far too inefficient. Inefficient designs waste power and performance and will quickly be surpassed by more adaptive designs, just as it happens in the biological realm. Organisms must adapt to survive, and a similar trend is seen with processors – those that are enabled to adapt to their environment, will be far more competitive. The adaptive processor needs to be made aware of its environment and operating conditions through the use of various sensors. It must then have some ability to usefully respond to the sensor stimulus. The focus of this book is not so much on a static configuration of each manufactured part that may be unique, but on *dynamic* adaptation, where the part optimizes itself on the fly.

Many different responses and adaptive approaches have been explored in recent years. These range from circuits that make voltage changes and set body biases to those that generate clock frequency adjustments on logic. New circuit techniques are needed to address the special challenges created by scaling embedded memories. Finally, system level techniques rely on self-correction in the processor logic or asynchronous techniques which remove the reliance on clocks. Each approach has unique challenges

and benefits, and it adds value in particular situations, but regardless of the method, the challenge of reliably testing these adaptive approaches looms as one of the largest. Hence the subtitle the book: Theory and Practice. Ideas (not necessarily good ones) on adaptive designs are easy to come by, but putting these in working silicon that demonstrates the benefits is much harder. The final level of achievement is actually productizing the capability in a high-volume manufacturing flow.

In order for the book to do justice to such a broad and relatively new topic, we invited authors who have already been pioneers in this area to present data on the approaches they have explored. Many of the authors presented at ISSCC2007, either in the Microprocessor Forum, or in the conference sessions. We are humbled to have collected contributions from such an impressive group of experts on the subject, many of whom have been pioneers in the field and produced results that will be impacting the processor design world for years to come. We believe this topic of adaptive design will continue to be a fertile area for research and integrated circuit improvements for the foreseeable future.

Alice Wang
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