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Series

Microprogrammable Parallel Computer

MUNAP and Its Applications

Takanobu Baba

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Series Foreword

This series is devoted to all aspects of computer systems. This means that subjects ranging from circuit components and microprocessors to architecture to supercomputers and systems programming will be appropriate. Analysis of systems will be important as well. System theories are developing, theories that permit deeper understanding of complex interrelationships and their effects on performance, reliability, and usefulness.

We expect to offer books that not only develop new material but also describe projects and systems. In addition to understanding concepts, we need to benefit from the decision making that goes into actual development projects; selection from various alternatives can be crucial to success. We are soliciting contributions in which several aspects of systems are classified and compared. A better understanding of both the similarities and the differences found in systems is needed.

It is an exciting time in the area of computer systems. New technologies mean that architectures that were at one time interesting but not feasible are now feasible. Better software engineering means that we can consider several software alternatives, instead of "more of the same old thing," in terms of operating systems and system software. Faster and cheaper communications mean that intercomponent distances are less important. We hope that this series contributes to this excitement in the area of computer systems by chronicling past achievements and publicizing new concepts. The format allows

publication of lengthy presentations that are of interest to a select readership.

Herb Schwetman

Preface

Since the advent of the computer we have witnessed many advances both in software and in hardware. In the field of software we now have various programming languages, compilers, and operating systems. In the field of hardware, VLSI (Very Large Scale Integrated) and new storage technologies have been developed; in the near future it will be possible to fabricate chips containing millions of transistors.

It is widely recognized that these advances in computer systems open up new areas for application - - and the advances in application in turn require more powerful computing systems. This rapidly growing demand can only be met by a radical change in computer architecture, where software and hardware are combined to provide powerful capabilities through parallel computation and thus flexibility for meeting a wide variety of user requirements.

This motivated us to design a new machine, called MUNAP, to show the effectiveness of low level parallel yet flexible architecture in various fields. After careful study the key concept of the machine was defined as a two-level microprogramming technology coupled with register transfer level, multiple instruction multiple data stream (MIMD) parallelism. The microprogramming was expected to enable us to tailor the machine to a wide spectrum of applications. The low level MIMD parallelism was expected to provide powerful computation

capability; it also suits the register level control by microprogramming. In the basic scheme, various primitive microoperations were provided mainly for nonnumeric processing.

This book describes all aspects of the innovative architecture in the following sequence:

Architecture design: After a short introduction in chapter 1, chapter 2 takes up several design issues, such as network and memory structures for MIMD parallelism, control structures for register transfer level parallelism, and selection of primitive operations for nonnumeric processing. Chapter 3 describes the architecture of a prototype machine. Chapter 4 evaluates the architecture, using microprogrammable parallel computer models. As they represent existing commercially available and experimental machines, this serves as a survey of machines with similar architecture.

Development: Chapters 5 and 6 describe the development of a prototype machine and supporting systems. Emphasis is placed on how we developed a large number of efficient microprograms for an MIMD parallel machine.

Applications: Chapter 7 describes the results of application in various fields. They include crucial issues in current computer architecture research: emulation, tagged architectures, language processing (such as a system description language, Prolog, and

Smalltalk-80), software testing, database systems, three-dimensional color graphics, and numerical computation. Each section includes the background of the subject, our approach to MUNAP, and experimental results. Throughout the descriptions, I have tried to clarify the effect of the architectural features.

Evaluation: Based on the application, chapter 8 evaluates the architecture. It also proposes and applies a systematic method for improving architecture. The method is so general that it can be applied to any other architecture. Chapter 9 discusses possible applications and alternatives of the architecture, considering the requirements from the VLSI viewpoint.

This book has two purposes: to introduce the MUNAP architecture and the results of its application to computer professionals in general, and for use as a textbook for people who want to design and develop a machine with innovative architecture. The reader is expected to have a good grasp of computer system fundamentals. In particular, the reader should be knowledgeable about computer system organizations, have an understanding of programming language processing, and have a grasp of the concept of microprogramming.

It is worth noting that the MUNAP architecture has a strong relationship to such recent architectural innovations as the very long instruction word (VLIW) architecture and the reduced instruction set computer (RISC) because it consists of two types

of simple instruction sets, the first level of instruction controlling multiple instructions at the second level. This can be viewed as a single VLIW architecture or a complex of RISC computers.

We believe that this book presents comprehensive research directions in the area of computer architecture, and we hope that it will encourage the people planning to develop a "next generation" computing system.

Acknowledgment

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At Utsunomiya University, my colleagues, Kenzo Okuda, Katsuhiro Yamazaki, and Ken Ishikawa, have led several research projects related to MUNAP, which enabled me to write this book. I am also grateful for their invaluable comments on the draft of this book.

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