Preface

It is well known that a continuing trend in the development of digital computers has been towards improved cost efficiency, leading to expansion into new applications. In large measure this trend has resulted from continuing improvements in component technology. Remarkable advances in the miniaturization and integration of electronic components, particularly in the past ten years, have ushered in an era of microelectronics in which improvements of unprecedented magnitude in the size, cost, performance, and reliability of computer systems have been achieved. The emergence of microprocessor technology has played an especially significant role in this progress.

Since the recognition in the late 1960s that it might be possible to achieve sufficiently high circuit densities to allow the basic elements of a central processing unit, or CPU, to be placed on a single chip of silicon, followed by the production of the first such chips in the early 1970s, microprocessors have captured the interest and imagination of product designers and technologists alike. This field has been one of the most exciting and productive areas of computer science and technology of the past decade. Today, microprocessors used as parts of microcomputers can simplify the process of system design by making the power of the digital computer available at the integrated circuit chip level.

The first microprocessors had limited instruction sets, were slow (by today's standards), and had only 4-bit data flows. These were followed in rapid succession by microprocessors with more extended architectures, enhanced functions, and faster instruction execution times. Today we have 8-bit, 16-bit, and even 32-bit microprocessors with considerably improved processing capabilities and performance. Most current microcomputers consist of one or more chips forming the CPU and associated storage, peripheral control, and other functions as required.

Microprocessors with either generalized or application-set-oriented architectures have been used extensively in lieu of conventional logic to achieve desired product functions. Among the advantages they offer are reduced hardware and production costs and increased reliability resulting from fewer part numbers and less complex packaging. But probably their most important advantage is their flexibility for change: product modifications often require only appropriate changes to the microprocessor programs. This can be a significant factor in reducing the time and expense involved in the incorporation of engineering changes and new product features, as well as product definition and development.

In recognition of the increasingly significant role that microprocessors are assuming in many areas of computer systems technology, this issue of the *IBM Journal of Research and Development* focuses on some of the recent major accomplishments in the area of microprocessor systems development at IBM. It contains a group of ten papers dealing with various aspects of a selected set of microprocessor development efforts and covers a generally broad range of disciplines. Taken together, these papers present a small but representative picture of the diversity of the work being performed. It is not the entire picture, of course, since that would require much more expanded treatment than space permits.

Microprocessors have found wide usage for product applications falling into the relatively low end of the performance-complexity spectrum, *e.g.*, terminals and displays, I/O controllers, word processors, and personal computers. However, products requiring higher performance and more complex functions have presented more formidable challenges to microprocessor implementation. In the first paper of this issue, Agnew and Kellerman examine new machine organizations and methods for applying large-scale integration and microprocessors to the design of processors with complex architectures at the lower performance end of the traditional mainframe processor spectrum. They consider a number of specific approaches for microprocessor-based implementations of System/370 functions. The most successful approaches partition the architecture and instruction set into subsets, each of which can be implemented either by special microcode on a microprocessor or by programs written for a normally microcoded microprocessor.

The next three papers focus on a microprocessor designed for signal processing, a domain of computing that includes speech, image, radar, sonar, data communications, seismic, and many other signal-oriented types of computer processing. But despite the diversity of applications, signal processing generally exhibits a structured set of characteristics, including a dominance of arithmetic operations, well-structured data flows, and real-time operation. The architecture and organization of this machine, a single-operand 16-bit fixed-point signal processor, are described in the paper by Mintzer and Peled. Some of its features include instruction pipelining, saturation arithmetic, a double-word-width accumulator, guard bits, and separate instruction and data stores. The architecture of the processor exploits the reduced computational complexity algorithms for Fourier Transforms and convolutions (filtering) which are the subject of the paper by Cooley on rectangular transforms. The new algorithms considerably reduce the number of multiplications necessary, although they require generally more complex program flows. A full set of software tools was developed for the microprocessor to make the overall hardware/software system more programmable; these aspects are discussed in the paper by Davies and Ris.

The application of microcontrollers for disk and diskette control functions is considered in the next paper, by Dix and Brown, which describes the architecture, functional organization, and design of a custom-designed FET chip being developed for use in these types of file controllers.

Following that, the paper by Correale discusses the physical design methodology used to produce a new 16-bit custom-macro-designed VLSI microprocessor to be used in general-purpose and industry-specific products. This chip is a complex arrangement of over 6500 equivalent circuits utilizing a state-of-the-art high-performance MOS technology.

In the concluding four papers, an in-depth account of the development of an advanced higher-performance VLSI microprocessor module and its design verification methodology is presented. Composed of four 3-ns bipolar technology chips containing over 15 000 equivalent logic circuits and a 50K-bit read-only storage, this module has the highest practical bipolar circuit density yet achieved at the module level by IBM. The processor includes an integrated channel as well as a storage addressing subsystem that provides dynamic address translation, relocation, and protection. The microprocessor architecture and its logical design are described in the paper by Campbell and Tahmoush. Chip design aspects are treated in the paper by Mathews and Lee, which also discusses the circuit technology and the chip structure. The logical design verification is the focus of the paper by Tran, Forsberg, and Lee, and the physical and electrical verification procedures are covered in the paper by McCabe and Muszynski.

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