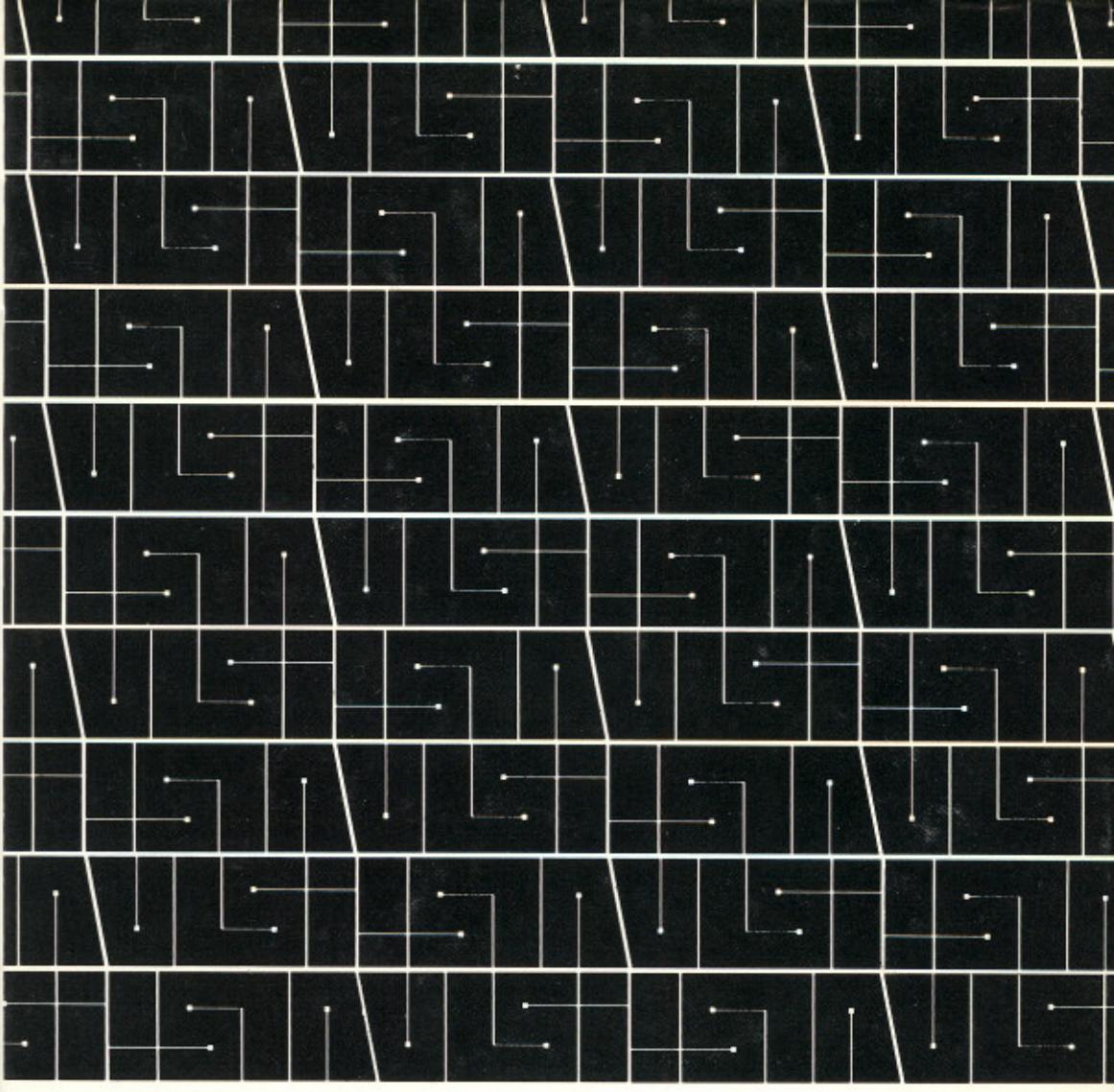
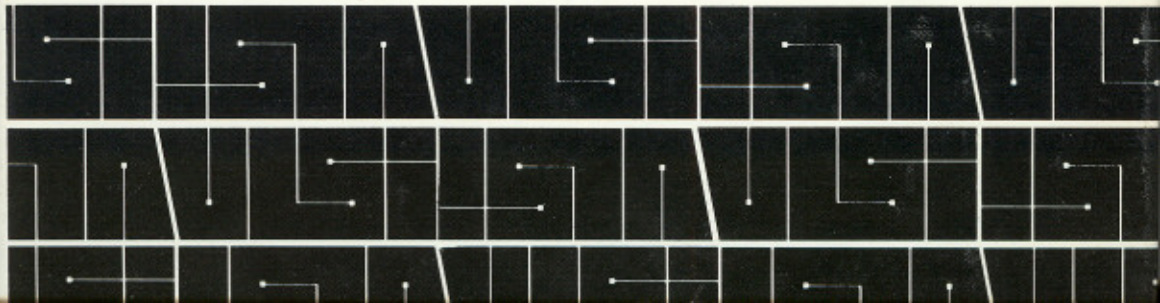


VLSI
SYSTEMS AND COMPUTATIONS

Editors:
H. T. KUNG, BOB SPROULL and GUY STEELE



Lynn Conway

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This volume consists of papers presented at Carnegie-Mellon University's *Conference on VLSI Systems and Computations,* October 19-21, 1981.

PREFACE

The papers in this book were presented at the *CMU Conference on VLSI Systems and Computations*, held October 19-21, 1981 in Pittsburgh, Pennsylvania. The conference was organized by the Computer Science Department, Carnegie-Mellon University and was partially supported by the National Science Foundation and the Office of Naval Research.

These proceedings focus on the theory and design of computational systems using VLSI. Until very recently, integrated-circuit research and development were concentrated in the device physics and fabrication design disciplines and in the integrated-circuit industry itself. Within the last few years, a community of researchers is growing to address issues closer to computer science: the relationship between computing structures and the physical structures that implement them; the specification and verification of computational processes implemented in VLSI; the use of massively parallel computing made possible by VLSI; the design of special-purpose computing architectures; and the changes in general-purpose computer architecture that VLSI makes possible. It is likely that the future exploitation of VLSI technology depends as much on structural and design innovations as on advances in fabrication technology.

The book is divided into nine sections:

- **Invited Papers.** Six distinguished researchers from industry and academia presented invited papers.
- **Models of Computation.** The papers in this section deal with abstracting the properties of VLSI circuits into models that can be used to analyze the chip area, time or energy required for a particular computation.
- **Complexity Theory.** This section shows how computations can be analyzed to obtain bounds on the resources (chip area, time, energy) required to perform some computation. The last paper in this section is a light-hearted reminder that complexity theories must acknowledge reality.
- **Layout Theory and Algorithms.** Papers in this section describe ways to route wires that connect together different circuits on a chip. This topic is of importance in computer-aided design, but also relates to the complexity of circuit layouts.
- **Languages and Verification.** This section presents several results on the specification and verification of circuits and of entire systems. The large number of communicating processes in some VLSI architectures must be designed methodically to insure proper operation.
- **Special-Purpose Architectures.** This section deals with systolic computing architectures and their application to areas such as signal processing.
- **Multiplier Designs.** The problem of designing an efficient multiplier is of both practical and theoretical interest. An important application for multipliers is in signal processing.
- **Processors.** Two papers in this section describe new designs for single-chip general-purpose computers whose architecture is influenced by VLSI design opportunities.
- **Systems and Processors.** This section contains papers describing frameworks for entire systems, such as parallel processing arrays and content-addressable memories.

These papers were selected by the program committee from among 120 extended abstracts submitted in response to the call for papers. Selection was based on originality and relevance to the theme of the conference, and was very difficult, owing to the large number of excellent papers submitted. Among the papers that could not be accepted were some excellent ones in design automation and computer-aided design, important areas beyond the scope of the conference.

We wish to express our thanks to the authors for making their works available while complying with strict deadlines and formats to aid in the timely appearance of the book; to the invited speakers for their excellent papers and for sharing their insights and experience; and to the program committee members for their careful evaluation of the many extended abstracts, despite the limited time made available to them. Especially, our grateful thanks go to Louis Monier, who contributed greatly in the planning of the conference and the publication of this book, and to Sharon Carmack, who was not only responsible for conference registration, but also handled the many details involved in the preparation of the conference.

The logo and cover design appearing on this book and throughout the conference were designed by E. Heidi Fieschko.

H. T. Kung and Bob Sproull

Fall 1981

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