KNOWLEDGE BASED CAD AND MICROELECTRONICS

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ABOUT THIS BOOK

Origins

This book is essentially the reproduction of the Author's Doctoral Thesis which was the result of work carried out between 1982 and 1985 at London University to investigate the applicability of knowledge based techniques to VLSI Computer Aided Design. Owing to the current strong interest in the question of how knowledge based techniques could be applied to VLSI CAD, it was suggested that the thesis should be reproduced for a wider audience.

How it was produced

The original Doctoral thesis was produced at London University using the Ded text editor running under UNIX on a DEC PDP11/44. The work was later transferred electronically to Cambridge University where the book and illustrations were produced with the aid of a Macintosh personal computer supporting Microsoft Word and MacDraw. The completed text was transferred onto magnetic tape.

"I put the words down and push them a bit"
Evelyn Waugh

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PREFACE

The motivations for this work

During a panel session at the 1985 International Joint Conference on Artificial Intelligence, held in Los Angeles, one of the panelists humourously suggested that Artificial Intelligence (AI) bore some resemblance to religious thinking on three bases: first, that of the atheist, who refuses to believe that it has any valid or rational basis whatsoever, and that problems ought to be solved by more down to earth techniques; secondly, that of the agnostic, who, while not entirely suspending disbelief, concedes that the ideas reveal possible benefits; and, finally, that of the worst type of television evangelist whose message is summarised thus: "Send me your money now, have faith and all your problems will disappear tomorrow!"

The following pages have their genesis in the doctoral work carried out by the author. This was directed towards investigating the applicability of AI techniques to those problems confronting the designers of very large scale integrated (VLSI) circuits, who are seeking to put to advantage the steady progress being made in the techniques of silicon fabrication, whereby hundreds of thousands of transistors may be accommodated on one single chip.

In view of the scarcity of knowledge about AI, particularly amongst industrial Computer Aided Design (CAD) designers and managers, and the way in which it is able to cope with modelling very large systems and make decisions about them, it was suggested that the thesis should be modified to make it presentable to a wider audience in the hope that some small benefit would ensue.

The audience and aims of this book

In writing this book, two classes of readers have been considered:

- Managers of VLSI CAD groups in industry who may have heard such terms as 'AI', 'Knowledge Based Systems' (KBS), 'LISP machines' or 'Object Orien-

tated Interactive Programming' and who are asking the question: "Well, what are 'AI techniques' and what do they have to offer me?"

– People who may be embarking upon an investigation of such techniques or on a project based upon AI and who could use the book as a case study in the application of Knowledge Based techniques in a non trivial area New graduate students are one category of person that immediately comes to mind in this context.

It is also submitted that the material is relevant to the objectives of designers and CAD people apart from those involved in VLSI, since it is as much a study on design as it is on building new VLSI CAD tools. Recognising that there may be readers who are not from VLSI or AI backgrounds, some chapters in this book have been set aside for presenting an introduction to the basic ideas, techniques and problems of these areas.

After reading this work, it is hoped that the reader will be better armed with the background necessary to begin an understanding of which aspects of his particular task may lend themselves to containment and solution within a knowledge based framework.

The bulk of the research on which this book is based was carried out in 1983-84 and in terms of the pace of technological progress in VLSI CAD this is a long time, therefore, many problems and conflicts of attitude described in the book have been resolved. This is particularly true in areas such as behavioural to layout synthesis techniques or 'silicon compilation' in addition to the acceptance and use of behavioural and object languages and even LISP.

It should perhaps be said that for some readers from industrial VLSI backgrounds it may, at first, appear odd to describe as being innovative and unfamiliar some of the ideas and techniques for building VLSI CAD systems contained within this book. However, it was not the object of this research to build a better layout generator, compactor, router or whatever. Instead, the aim was to investigate the feasibility of uniting the hitherto unconnected areas of knowledge based systems, object orientated programming and VLSI CAD techniques and philosophy. In order to do this, well understood and 'solved' tasks in VLSI were used as vehicles upon which to try out KBS ideas. With this in mind, the reasons for the existence of the various contents of the book should be clear.

I have preferred to describe the work under the heading of 'Knowledge Based' rather than 'Artificial Intelligence'. This preference stems from the historical fact that the latter expression has tended to be identified with more established

areas of speech and vision research, that have developed their own very specialised techniques. Knowledge Based Techniques generally refer to a subset of all AI techniques and these are the set used for the VLSI work described here. Although others may disagree, I have also elected to include object orientated programming and modelling under this former heading because of the conceptual similarities that this area and frame-based programming from AI share. They have therefore been used within this interpretation in this book.

The contents of the chapters

The plan of the book is as follows; it is left to the reader to decide which chapters require closer scrutiny and which may be skimmed or even passed over.

- For those readers unfamiliar with KBS techniques, Chapter One provides an introduction to the philosophy of symbolic and other knowledge based representation techniques and the capabilities these offer over more conventional and algorithmic techniques.

- Chapter Two discusses how these principles may be embodied in heuristic 'rules' in order that practical and useful 'expert systems' may be produced. Included also is a description of the important AI language LISP.

- Chapter Three outlines the structure and typical components of a knowledge based system.

- The use of rules, objects and other formalisms for building complex knowledge based constructs and systems is explained in Chapter Four.

- For those readers from a non-VLSI background, Chapter Five provides an introduction of what VLSI design is together with a survey of what the various tasks and problems in VLSI CAD are - including some explanation of how these are solved by conventional means. An outline is given of some of the orthodox representation constructs that have been developed for describing a VLSI circuit in its different forms.

This book is not designed, nor was it ever contemplated, as being a full tutorial, manual or discussion upon either AI or VLSI. It is merely for completeness that the foregoing sections have been included. In so doing, the author seeks to direct a reader from one area into that of another and thereby secure an understanding of the problems and ideas involved. A selection of books giving a more

complete and detailed exposition of these areas will be found in the appendixes.

It is as well to appreciate that there are many tasks in VLSI design which can be approached perfectly well using conventional algorithmically based techniques. No material benefit would be conferred upon commercial users from a knowledge based solution if a conventional one would suffice. KBS's invariably include components based upon a designer's "heuristic" understanding of his work and not upon any sound formal theories. AI for AI's sake is not always a wise commercial move.

– This leads on to Chapter Six which describes, notwithstanding the point above, what design is from a KBS viewpoint and how it can be modelled to useful effect. Outlined is the ability to perceive design as a series of transformations, descending from an initially very abstract statement of requirement ("I want to build a .....") down through a behavioural specification, circuit diagram and finally, to an exact specification of rectangles on a mask. Included also is a discussion about the types of areas of VLSI design that may profitably lend themselves to solution by knowledge based rather than orthodox techniques.

– In his practical work, the author was motivated by a desire to investigate the feasibility of constructing a high level design language *toolkit* which a designer could employ in the construction of his own system for performing a range of these design transformations. The greater part of this practical research has been embodied in Chapter Seven. It is presented as a case study on how to set about building such a toolkit and how each AI paradigm is applied and integrated. It must be emphasised that building a "real" toolkit is an enormous task and the most the author could do, even by drawing upon the entirety of his research, would be merely to map out the routes to be followed. As vehicles for the development of these techniques, the author concentrated upon the specific tasks of: a) the way in which a sticks or symbolic circuit representation might be transformed to mask layout; and b) the way in which a functional description for a circuit could be extracted from a circuit diagram using these techniques.

However, as this work was progressing, the commercially produced toolkit LOOPS appeared. Owing to the far greater number of man-years of development effort invested in LOOPS it was a much more complete and usable tool, therefore all experimental work was transfered away from the author's own system and onto LOOPS. Chapter Eight describes LOOPS and this work.

– Chapter Nine surveys a selection of other knowledge based VLSI CAD work.

In addition to LOOPS, other shells and toolkits for constructing knowledge based systems have been commercially developed. Evolving alongside these (predominantly LISP based) languages, is a whole philosophy of interactive, exploratory program design. These techniques, and the machines and systems which support them, may be unfamiliar within some commercial CAD environments therefore a brief survey of these systems is given in Chapter Ten.

Chapter Eleven aims to offer further assistance to those commercial CAD managers who may wish to know more about about assessing the viability of setting up KBS projects. In this chapter therefore is some material on the applicability of KBS techniques to problems in general.

Finally comes Chapter Twelve. This discusses the material of the foregoing chapters and assesses the future outlook for knowledged based VLSI CAD. Also included is a more speculative look at what the next advances may bring. It also gives some thought on how *intelligent assistants* could be built to help the designer at the very highest levels of design transformation, for example, taking his "I want to build a . ." and then producing a behavioural specification. Achievement of this goal would be of immense value since it seems likely that present research will soon result in commercially viable systems for taking a completed behavioural specification and automatically producing layout.

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