

Preface

Denotational semantics is a methodology for giving mathematical meaning to programming languages and systems. It was developed by Christopher Strachey's Programming Research Group at Oxford University in the 1960s. The method combines mathematical rigor, due to the work of Dana Scott, with notational elegance, due to Strachey. Originally used as an analysis tool, denotational semantics has grown in use as a tool for language design and implementation.

This book was written to make denotational semantics accessible to a wider audience and to update existing texts in the area. I have presented the topic from an engineering viewpoint, emphasizing the descriptive and implementational aspects. The relevant mathematics is also included, for it gives rigor and validity to the method and provides a foundation for further research.

The book is intended as a tutorial for computing professionals and as a text for university courses at the upper undergraduate or beginning graduate level. The reader should be acquainted with discrete structures and one or more general purpose programming languages. Experience with an applicative-style language such as LISP, ML, or Scheme is also helpful.

CONTENTS OF THE BOOK

The Introduction and Chapters 1 through 7 form the core of the book. The Introduction provides motivation and a brief survey of semantics specification methods. Chapter 1 introduces BNF, abstract syntax, and structural induction. Chapter 2 lists those concepts of set theory that are relevant to semantic domain theory. Chapter 3 covers semantic domains, the value sets used in denotational semantics. The fundamental domains and their related operations are presented. Chapter 4 introduces basic denotational semantics. Chapter 5 covers the semantics of computer storage and assignment as found in conventional imperative languages. Nontraditional methods of store evaluation are also considered. Chapter 6 presents least fixed point semantics, which is used for determining the meaning of iterative and recursive definitions. The related semantic domain theory is expanded to include complete partial orderings; "predomains" (complete partial orderings less "bottom" elements) are used. Chapter 7 covers block structure and data structures.

Chapters 8 through 12 present advanced topics. Tennent's analysis of procedural abstraction and general binding mechanisms is used as a focal point for Chapter 8. Chapter 9 analyzes forms of imperative control and branching. Chapter 10 surveys techniques for converting a denotational definition into a computer implementation. Chapter 11 contains an overview of Scott's inverse limit construction for building recursively defined domains. Chapter 12 closes the book with an introduction to methods for understanding nondeterminism and concurrency.

Throughout the book I have consistently abused the noun "access," treating it as a verb. Also, "iff" abbreviates the phrase "if and only if."

ORGANIZATION OF A COURSE ---

The book contains more material than what can be comfortably covered in one term. A course plan should include the core chapters; any remaining time can be used for Chapters 8 through 12, which are independent of one another and can be read in any order. The core can be handled as follows:

- Present the Introduction first. You may wish to give a one lecture preview of Chapter 4. A preview motivates the students to carefully study the material in the background Chapters 1 through 3.
- Cover all of Chapters 1 and 2, as they are short and introduce crucial concepts.
- Use Chapter 3 as a “reference manual.” You may wish to start at the summary Section 3.5 and outline the structures of semantic domains. Next, present examples of semantic algebras from the body of the chapter.
- Cover all of Chapter 4 and at least Sections 5.1 and 5.4 from Chapter 5. If time allows, cover all of Chapter 5.
- Summarize Chapter 6 in one or two lectures for an undergraduate course. This summary can be taken from Section 6.1. A graduate course should cover all of the chapter.
- Cover as much of Chapter 7 as possible.

REFERENCES AND EXERCISES ---

Following each chapter is a short list of references that suggests further reading. Each reference identifies the author and the year of publication. Letters *a*, *b*, *c*, and so on, are used if the author has multiple references for a year. The references are compiled in the bibliography in the back of the book. I have tried to make the bibliography current and complete, but this appears to be an impossible task, and I apologize to those researchers whose efforts I have unintentionally omitted.

Exercises are provided for each chapter. The order of a chapter’s exercises parallels the order of presentation of the topics in the chapter. The exercises are not graded according to difficulty; an hour’s effort on a problem will allow the reader to make that judgment and will also aid development of intuitions about the significant problems in the area.

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I would be pleased to receive comments and corrections from the readers of this book.