Language Proof And Logic Chapter 8 Solutions

This monograph studies the logical aspects of domains as used in de notational semantics of programming languages. Frameworks of domain logics are introduced; these serve as foundations for systematic derivations of proof systems from denotational semantics of programming languages. Any proof system so derived is guaranteed to agree with denotational se mantics in the sense that the denotation of any program coincides with the set of assertions true of it. The study focuses on two categories for dena tational semantics: SFP domains, and the less standard, but important, category of stable domains. The intended readership of this monograph includes researchers and graduate students interested in the relation between semantics of program ming languages and formal means of reasoning about programs. A basic knowledge of denotational semantics, mathematical logic, general topology, and category theory is helpful for a full understanding of the material. Part I SFP Domains Chapter 1 Introduction This chapter provides a brief exposition to domain theory, denotational se mantics, program logics, and proof systems. It discusses the importance of ideas and results on logic and topology to the understanding of the relation between denotational semantics and program logics. It also describes the motivation for the work presented by this monograph, and how that work fits into a more general program. Finally, it gives a short summary of the results of each chapter. 1. 1 Domain Theory Programming languages are languages with which to perform computa tion.

Language, Proof, and LogicSeven Bridges PressLlc

This book is a specialized monograph on the development of the mathematical and computational metatheory of reductive logic and proof-search, areas of logic that are becoming important in computer science. A systematic foundational text on these emerging topics, it includes proof-theoretic, semantic/model-theoretic and algorithmic aspects. The scope ranges from the conceptual background to reductive logic, through its mathematical metatheory, to its modern applications in the computational sciences. Suitable for researchers and graduate students in mathematical, computational and philosophical logic, and in theoretical computer science and artificial intelligence, this is the latest in the prestigous world-renowned Oxford Logic Guides, which contains Michael Dummet's Elements of intuitionism (2nd Edition), Dov M. Gabbay, Mark A. Reynolds, and Marcelo Finger's Temporal Logic Mathematical Foundations and Computational Aspects , J. M. Dunn and G. Hardegree's Algebraic Methods in Philosophical Logic, H. Rott's Change, Choice and Inference: A Study of Belief Revision and Nonmonotonic Reasoning , and P. T. Johnstone's Sketches of an Elephant: A Topos Theory Compendium: Volumes 1 and 2 .

Logic Primer presents a rigorous introduction to natural deduction systems of sentential and first-order logic. Logic Primer presents a rigorous introduction to natural deduction systems of sentential and first-order logic. The text is designed to foster the student-instructor relationship. The key concepts are laid out in concise definitions and comments, with the expectation that the instructor will elaborate upon them. New to the second edition is the addition of material on the logic of identity in chapters 3 and 4. An innovative interactive Web site, consisting of a "Logic Daemon" and a "Quizmaster," encourages students to formulate their own proofs and links them to appropriate explanations in the book.

Reductive Logic and Proof-search

The Language of First-Order Logic, Including the Macintosh Program Tarski's World 4.0

Applications and Theory

Time & Logic

Symbolic Logic

Proof Theory, Semantics, and Control

Perspectives in Computing: A Computational Logic Handbook contains a precise description of the logic and a detailed reference guide to the associated mechanical theorem proving system, including a primer for the logic as a functional programming language, an introduction to proofs in the logic, and a primer for the mechanical theorem. The publication first offers information on a primer for the logic, formalization within the logic, and a precise description of the logic. Discussions focus on induction and recursion, quantification, explicit value terms, dealing with features and omissions, elementary mathematical relationships, Boolean operators, and conventional data structures. The text then takes a look at proving theorems in the logic, mechanized proofs in the logic, and an introduction to the system. The text examines the processes involved in using the theorem prover, four classes of rules generated from lemmas, and aborting or interrupting commands. Topics include executable counterparts, toggle, elimination of irrelevancy, heuristic use of equalities, representation of formulas, type sets, and the crucial check points in a proof attempt. The publication is a vital reference for researchers interested in computational logic.

Originally published in 1995 Time and Logic examines understanding and application of temporal logic, presented in computational terms. The emphasis in the book is on presenting a broad range of approaches to computational applications. The techniques used will also be applicable in many cases to formalisms beyond temporal logic alone, and it is hoped that adaptation to many different logics of program will be facilitated. Throughout, the authors have kept implementation-orientated solutions in mind. The book begins with an introduction to the basic ideas of temporal logic. Successive chapters examine particular aspects of the temporal theoretical computing domain, relating their applications to familiar areas of research, such as stochastic process theory, automata theory, established proof systems, model checking, relational logic and classical predicate logic. This is an essential addition to the library of all theoretical computer scientists. It is an authoritative work which will meet the needs both of those familiar with the field and newcomers to it.

The Logic of Our Language teaches the practical and everyday application of formal logic. Rather than overwhelming the reader with abstract theory, Jackson and McLeod show how the skills developed through the practice of logic can help us to better understand our own language and reasoning processes. The authors ' goal is to draw attention to the patterns and logical structures inherent in our spoken and written language by teaching the reader how to translate English sentences into formal symbols. Other logical tools, including truth tables, truth trees, and natural deduction, are then introduced as techniques for examining the properties of symbolized sentences and assessing the validity of arguments. A substantial number of practice questions are offered both within the book itself and as interactive activities on a companion website.

The logical study of language is becoming more interdisciplinary, playing a role in fields such as computer science, artificial intelligence, cognitive science and game theory. This new edition, written by the leading experts in the field, presents an overview of the latest developments at the interface of logic and linguistics as well as a historical perspective. It is divided into three parts covering Frameworks, General Topics and Descriptive Themes. Completely revised and updated - includes over 25% new material Discusses the interface between logic and language Many of the authors are creators or active developers of the theories

The Mathematician's Toolbox

Logic Primer, second edition

Discrete Mathematics

Language, Truth and Logic

Language, Proof, and Logic

An Open Introduction

The Handbook of Logic in Artificial Intelligence and Logic Programming is a multi-volume work covering all major areas of the application of logic to artificial intelligence and logic programming. The authors are chosen on an international basis and are leaders in the fields covered. Volume 5 is the last in this well-regarded series. Logic is now widely recognized as one of the foundational disciplines of computing. It has found applications in virtually all aspects of the subject, from software and hardware engineering to programming languages and artificial intelligence. In response to the growing need for an in-depth survey of these applications the Handbook of Logic in Artificial Intelligence and its companion, the Handbook of Logic in Computer Science have been created. The Handbooks are a combination of authoritative exposition, comprehensive survey, and fundamental research exploring the underlying themes in the various areas. Some mathematical background is assumed, and much of the material will be of interest to logicians and mathematicians. Volume 5 focuses particularly on logic programming. The chapters, which in many cases are of monograph length and scope, emphasize possible unifying themes.

"Forall x is an introduction to sentential logic and first-order predicate logic with identity, logical systems that significantly influenced twentieth-century analytic philosophy. After working through the material in this book, a student should be able to understand most quantified expressions that arise in their philosophical reading. This books treats symbolization, formal semantics, and proof theory for each language. The discussion of formal semantics is more direct than in many introductory texts. Although forall x does not contain proofs of soundness and completeness, it lays the groundwork for understanding why these are things that need to be proven. Throughout the book, I have tried to highlight the choices involved in developing sentential and predicate logic. Students should realize that these two are not the only possible formal languages. In translating to a formal language, we simplify and profit in clarity. The simplification comes at a cost, and different formal languages are suited to translating different parts of natural language. The book is designed to provide a semester's worth of material for an introductory college course. It would be possible to use the book only for sentential logic, by skipping chapters 4-5 and parts of chapter 6"--Open Textbook Library.

Logic for Philosophy is an introduction to logic for students of contemporary philosophy. It is suitable both for advanced undergraduates and for beginning graduate students in philosophy. It covers (i) basic approaches to logic, including proof theory and especially model theory, (ii) extensions of standard logic that are important in philosophy, and (iii) some elementary philosophy of logic. It emphasizes breadth rather than depth. For example, it discusses modal logic and counterfactuals, but does not prove the central metalogical results for predicate logic (completeness, undecidability, etc.) Its goal is to introduce students to the logic they need to know in order to read contemporary philosophical work. It is very user-friendly for students without an extensive background in mathematics. In short, this book gives you the understanding of logic that you need to do philosophy.

Table of contents

Forall X

Handbook of Philosophical Logic

Handbook of Logic and Language

The Semantic Foundations of Logic

The Logic of Our Language

The eighth volume of the Second Edition contains major contributions on the Logic of Questions, Sequent Systems for Modal Logics, Deontic Logic as well as Deontic Logic and Contrary-to-duties. Audience: Students and researchers whose work or interests involve philosophical logic and its applications.

The Language of First-Order Logic is a complete introduction to first-order symbolic logic, consisting of a computer program and a text. The program, an aid to learning and using symbolic notation, allows one to construct symbolic sentences and possible worlds, and verify that a sentence is well formed. The truth or falsity of a sentence can be determined by playing a deductive game with the computer.

Rev. ed. of: Language, proof, and logic / Jon Barwise & John Etchemendy.

Brimming with visual examples of concepts, derivation rules, and proof strategies, this introductory text is ideal for students with no previous experience in logic. Students will learn translation both from formal language into English and from English into formal language; how to use truth trees and truth tables to test propositions for logical properties; and how to construct and strategically use derivation rules in proofs.

Language in Action

The Logic of Mathematical Discovery

Classical Mathematical Logic

Formerly Notes and Reports in Computer Science and Applied Mathematics

Mathematical Logic

Syntax, Semantics, and Proof

This comprehensive overview ofmathematical logic is designedprimarily for advanced undergraduatesand graduate studentsof mathematics. The treatmentalso contains much of interest toadvanced students in computerscience and philosophy. Topics include propositional logic;first-order languages and logic; incompleteness, undecidability,and indefinability; recursive functions; computability;and Hilbert's Tenth Problem.Reprint of the PWS Publishing Company, Boston, 1995edition.

This accessible textbook gives beginning undergraduate mathematics students a first exposure to introductory logic, proofs, sets, functions, number theory, relations, finite and infinite sets, and the foundations of analysis. The book provides students with a quick path to writing proofs and a practical collection of tools that they can use in later mathematics courses such as abstract algebra and analysis. The importance of the logical structure of a mathematical statement as a framework for finding a proof of that statement, and the proper use of variables, is an early and consistent theme used throughout the book.

Language in Action demonstrates the viability of mathematical research into the foundations of categorial grammar, a topic at the border between logic and linguistics. Since its initial publication it has become the classic work in the foundations of categorial grammar. A new introduction to this paperback edition updates the open research problems and records relevant results through pointers to the literature. Van Benthem presents the categorial processing of syntax and semantics as a central component in a more general dynamic logic of information flow, in tune with computational developments in artificial intelligence and cognitive science. Using the paradigm of categorial grammar, he describes the substructural logics driving the dynamics of natural language syntax and semantics. This is a general type-theoretic approach that lends itself easily to proof-theoretic and semantic studies in tandem with standard logic. The emphasis is on a broad landscape of substructural categorial logics and their proof-theoretical and semantic peculiarities. This provides a systematic theory for natural language understanding, admitting of significant mathematical results. Moreover, the theory makes possible dynamic interpretations that view natural languages as programming formalisms for various cognitive activities.

This book is intended for students in computer science, formal linguistics, mathematical logic and to colleagues interested in categorial grammars and their logical foundations. These lecture notes present categorial grammars as deductive systems, in the approach called parsing-as-deduction, and the book includes detailed proofs of their main properties. The papers are organized in topical sections on AB grammars, Lambek's syntactic calculus, Lambek calculus and montague grammar, non-associative Lambek calculus, multimodal Lambek calculus, Lambek calculus, linear logic and proof nets and proof nets for the multimodal Lambek calculus.

Logic for Philosophy

Volume 8

An Introduction for programmers

Logic Made Easy: How to Know When Language Deceives You

Logic: Deductive and Inductive

A deductive account of natural language syntax and semantics

Note: This is the 3rd edition. If you need the 2nd edition for a course you are taking, it can be found as a "other format" on amazon, or by searching its isbn: 1534970746 This gentle introduction to discrete mathematics is written for first and second year math majors, especially those who intend to teach. The text began as a set of lecture notes for the discrete mathematics course at the University of Northern Colorado. This course serves both as an introduction to topics in discrete math and as the "introduction to proof" course for math majors. The course is usually taught with a large amount of student inquiry, and this text is written to help facilitate this. Four main topics are covered: counting, sequences, logic, and graph theory. Along the way proofs are introduced, including proofs by contradiction, proofs by induction, and combinatorial proofs. The book contains over 470 exercises, including 275 with solutions and over 100 with hints. There are also Investigate! activities throughout the text to support active, inquiry based learning. While there are many fine discrete math textbooks available, this text has the following advantages: It is written to be used in an inquiry rich course. It is written to be used in a course for future math teachers. It is open source, with low cost print editions and free electronic editions. This third edition brings improved exposition, a new section on trees, and a bunch of new and improved exercises. For a complete list of changes, and to view the free electronic version of the text, visit the book's website at discrete.openmathbooks.org

This is a short, modern, and motivated introduction to mathematical logic for upper undergraduate and beginning graduate students in mathematics and computer science. Any mathematician who is interested in getting acquainted with logic and would like to learn Gödel's incompleteness theorems should find this book particularly useful. The treatment is thoroughly mathematical and prepares students to branch out in several areas of mathematics related to foundations and computability, such as logic, axiomatic set theory, model theory, recursion theory, and computability. In this new edition, many small and large changes have been made throughout the text. The main purpose of this new edition is to provide a healthy first introduction to model theory, which is a very important branch of logic. Topics in the new chapter include ultraproduct of models, elimination of quantifiers, types, applications of types to model theory, and applications to algebra, number theory and geometry. Some proofs, such as the proof of the very important completeness theorem, have been completely rewritten in a more clear and concise manner. The new edition also introduces new topics, such as the notion of elementary class of structures, elementary diagrams, partial elementary maps, homogeneous structures, definability, and many more.

"A delightful book … I should like to have written it myself." — Bertrand Russell First published in 1936, this first full-length presentation in English of the Logical Positivism of Carnap, Neurath, and others has gone through many printings to become a classic of thought and communication. It not only surveys one of the most important areas of modern thought; it also shows the confusion that arises from imperfect understanding of the uses of language. A first-rate antidote for fuzzy thought and muddled writing, this remarkable book has helped philosophers, writers, speakers, teachers, students, and general readers alike. Mr. Ayers sets up specific tests by which you can easily evaluate statements of ideas. You will also learn how to distinguish ideas that cannot be verified by experience — those expressing religious, moral, or aesthetic experience, those expounding theological or metaphysical doctrine, and those dealing with a priori truth. The basic thesis of this work is that philosophy should not squander its energies upon the unknowable, but should perform its proper function in criticism and analysis.

This introductory graduate text covers modern mathematical logic from propositional, first-order and infinitary logic and Gödel's Incompleteness Theorems to extensive introductions to set theory, model theory and recursion (computability) theory. Based on the author's more than 35 years of teaching experience, the book develops students' intuition by presenting complex ideas in the simplest context for which they make sense. The book is appropriate for use as a classroom text, for self-study, and as a reference on the state of modern logic.

The Metaphysics of Logic

Articulating Medieval Logic

Categories, Lambdas and Dynamic Logic

Proof, Logic, and Conjecture

A Course on Mathematical Logic

An Introduction to Symbolic Logic

Formal systems that describe computations over syntactic structures occur frequently in computer science. Logic programming provides a natural framework for encoding and animating such systems. However, these systems often embody variable binding, a notion that must be treated carefully at a computational level. This book aims to show that a programming language based on a simply typed version of higher-order logic provides an elegant, declarative means for providing such a treatment. Three broad topics are covered in pursuit of this goal. First, a proof-theoretic framework that supports a general view of logic programming is identified. Second, an actual language called ?Prolog is developed by applying this view to higher-order logic. Finally, a methodology for programming with specifications is exposed by showing how several computations over formal objects such as logical formulas, functional programs, and ?-terms and ?-calculus expressions can be encoded in ?Prolog.

Proofs and Refutations is for those interested in the methodology, philosophy and history of mathematics.

This wide-ranging collection of essays explores the nature of logic and the key issues and debates in the metaphysics of logic.

The new edition of a comprehensive and rigorous but concise introduction to symbolic logic. Logic Primer offers a comprehensive and rigorous introduction to symbolic logic, providing concise definitions of key concepts, illustrative examples, and exercises. After presenting the definitions of validity and soundness, the book goes on to introduce a formal language, proof theory, and formal semantics for sentential logic (chapters 1–3) and for first-order predicate logic (chapters 4–6) with identity (chapter 7). For this third edition, the material has been reorganized from four chapters into seven, increasing the modularity of the text and enabling teachers to choose alternative paths through the book. New exercises have been added, and all exercises are now arranged to support students moving from easier to harder problems. Its spare and elegant treatment makes Logic Primer unique among textbooks. It presents the material with minimal chattiness, allowing students to proceed more directly from topic to topic and leaving instructors free to cover the subject matter in the way that best suits their students. The book includes more than thirty exercise sets, with answers to many of them provided in an appendix. The book's website allows students to enter and check proofs, truth tables, and other exercises interactively.

An Introduction to Mathematical Logic

Proofs and Refutations

A Computational Logic Handbook
The Tools of Mathematical Reasoning
Logic Primer, third edition
Handbook of Logic in Artificial Intelligence and Logic Programming: Volume 5: Logic Programming

This leading text for symbolic or formal logic courses presents all techniques and concepts with clear, comprehensive explanations, and includes a wealth of carefully constructed examples. Its flexible organization (with all chapters complete and self-contained) allows instructors the freedom to cover the topics they want in the order they choose.

This book presents the author's research on automatic learning procedures for categorial grammars of natural languages. The research program spans a number of intertwined disciplines, including syntax, semantics, learnability theory, logic, and computer science. The theoretical framework employed is an extension of categorial grammar that has come to be called multimodal or type-logical grammar. The first part of the book presents an expository summary of how grammatical sentences of any language can be deduced with a specially designed logical calculus that treats syntactic categories as its formulae. Some such Universal Type Logic is posited to underlie the human language faculty, and all linguistic variation is captured by the different systems of semantic and syntactic categories which are assigned in the lexicons of different languages. The remainder of the book is devoted to the explicit formal development of computer algorithms which can learn the lexicons of type logical grammars from learning samples of annotated sentences. The annotations consist of semantic terms expressed in the lambda calculus, and may also include an unlabeled tree-structuring over the sentence. The major features of the research include the following: We show how the assumption of a universal linguistic component---the logic of language---is not incompatible with the conviction that every language needs a different system of syntactic and semantic categories for its proper description. The supposedly universal linguistic categories descending from antiquity (noun, verb, etc.) are summarily discarded. Languages are here modeled as consisting primarily of sentence trees labeled with semantic structures; a new mathematical class of such term-labeled tree languages is developed which cross-cuts the well-known Chomsky hierarchy and provides a formal restrictive condition on the nature of human languages. The human language acquisition mechanism is postulated to be biased, such that it assumes all input language samples are drawn from the above "syntactically homogeneous" class; in this way, the universal features of human languages arise not just from the innate logic of language, but also from the innate biases which govern language learning. This project represents the first complete explicit attempt to model the aquisition of human language since Steve Pinker's groundbreaking 1984 publication, "Language Learnability and Language Development."

Terence Parsons presents a new study of the development and logical complexity of medieval logic. Basic principles of logic were used by Aristotle to prove conversion principles and reduce syllogisms. Medieval logicians expanded Aristotle's notation in several ways, such as quantifying predicate terms; and with the enlarged notation come additional logical principles. The resulting system of logic is able to deal with relational expressions, as in De Morgan'spuzzles about heads of horses. Parsons argues that medieval logic is as rich as contemporary first-order symbolic logic, though its full potential was not envisaged at the time. He provides a detailedexamination of the theory of modes of common personal supposition, and the useful principles of logic included with it. An appendix discusses the artificial signs introduced in the fifteenth century to alter quantifier scope.

This text presents a language-based logic for procedures to derive computer programs from formal specifications. This approach is based upon design philosophy, and the author has set out to use language that is easy to understand. The method has also been class-tested throughout its development, and features examples, solved exercises and explanations.

Programming with Higher-Order Logic
Proof and Disproof in Formal Logic
Logical Derivation of Computer Programs
The Logic Book
An Introduction to Formal Logic
Eliminating The Universe: Logical Properties Of Natural Language

"The best introduction to logic you will find."—Martin Gardner "Professor Bennett entertains as she instructs," writes Publishers Weekly about the penetrating yet practical Logic Made Easy. This brilliantly clear and gratifyingly concise treatment of the ancient Greek discipline identifies the illogical in everything from street signs to tax forms. Complete with puzzles you can try yourself, Logic Made Easy invites readers to identify and ultimately remedy logical slips in everyday life. Designed with dozens of visual examples, the book guides you through those hair-raising times when logic is at odds with our language and common sense. Logic Made Easy is indeed one of those rare books that will actually make you a more logical human being.

"Logic: Deductive and Inductive" by Carveth Read. Published by Good Press. Good Press publishes a wide range of titles that encompasses every genre. From well-known classics & literary fiction and non-fiction to forgotten−or yet undiscovered gems−of world literature, we issue the books that need to be read. Each Good Press edition has been meticulously edited and formatted to boost readability for all e-readers and devices. Our goal is to produce eBooks that are user-friendly and accessible to everyone in a high-quality digital format.

Proof and Disproof in Formal Logic is a lively and entertaining introduction to formal logic providing an excellent insight into how a simple logic works. Formal logic allows you to check a logical claim without considering what the claim means. This highly abstracted idea is an essential and practical part of computer science. The idea of a formal system—a collection of rules and axioms which define a universe of logical proofs—is what gives us programming languages and modern-day programming. This book concentrates on using logic as a tool: making and using formal proofs and disproofs of particular logical claims. The logic it uses—natural deduction—is very small and very simple; working with it helps you see how large mathematical universes can be built on small foundations. The book is divided into four parts: · Part I "Basics" gives an introduction to formal logic with a short history of logic and explanations of some technical words. · Part II "Formal syntactic proof" show you how to do calculations in a formal system where you are guided by shapes and never need to think about meaning. Your experiments are aided by Jape, which can operate as both inquisitor and oracle. · Part III "Formal semantic disproof" shows you how to construct mathematical counterexamples to show that proof is impossible. Jape can check the counterexamples you build. · Part IV "Program specification and proof" describes how to apply your logical understanding to a real computer science problem, the accurate description and verification of programs. Jape helps, as far as arithmetic allows. Aimed at undergraduates and graduates in computer science, logic, mathematics, and philosophy, the text includes reference to and exercises based on the computer software package Jape, an interactive teaching and research tool designed and hosted by the author that is freely available on the web.

In Classical Mathematical Logic, Richard L. Epstein relates the systems of mathematical logic to their original motivations to formalize reasoning in mathematics. The book also shows how mathematical logic can be used to formalize particular systems of mathematics. It sets out the formalization not only of arithmetic, but also of group theory, field theory, and linear orderings. These lead to the formalization of the real numbers and Euclidean plane geometry. The scope and limitations of modern logic are made clear in these formalizations. The book provides detailed explanations of all proofs and the insights behind the proofs, as well as detailed and nontrivial examples and problems. The book has more than 550 exercises. It can be used in advanced undergraduate or graduate courses and for self-study and reference. Classical Mathematical Logic presents a unified treatment of material that until now has been available only by consulting many different books and research articles, written with various notation systems and axiomatizations.

Logic of Domains
A Computational Approach
The Logic of Categorial Grammars
Fundamentals of Mathematical Logic
On the Logic and Learning of Language
A Concise Introduction to Logic

This text is designed to teach students how to read and write proofs in mathematics and to acquaint them with how mathematicians investigate problems and formulate conjecture.

Covers first-order language in method appropriate for first and second courses in logic. CD-ROM consists of a new book, 3 programs, and an Internet-based grading service.

This book synthesizes the author's work (1980s-2015) on the logical expressive power of natural language. It extends the tools and concepts of model theory as used in (higher order) predicate logic to the study of natural language semantics. It focuses on boolean structure, generalized quantification (separated from variable binding), covering some cases of anaphora. Different categories — predicates, adjective, quantifiers — are modeled by non-isomorphic boolean lattices.Of empirical linguistic interest is the expressibility of many natural classes of quantifiers defined in terms of their logical (automorphism invariant) properties. Some of these correlate with classes used syntactically in generative grammar. In other cases we find general (possibly universal) constraints on possible quantifier denotations in natural language.Also of novel logical interest are entailment paradigms that depend on relations between pairs or triples of generalized quantifier denoting expressions, ones that are in some cases inherently vague. In addition we note novel binary quantifiers that lie beyond the 'Frege boundary' in that they are provably not identical to any iterated application of unary quantifiers.Of philosophical interest is the existence of models which make the same sentences true as standard models but which lack a universe and hence, seemingly, a notion of 'reference'. Moreover, these models generalize to ones in which we can represent (some) intensional expressions without the use of novel ontological objects, such as 'possible worlds' or 'propositions'.