

CONTENTS IN DETAIL

ACKNOWLEDGMENTS	xvii
INTRODUCTION	xix
Who Should Read This Book	xx
Organization and Requirements	xi
Modern Features	xxiii
Why Value Types?	xxiii
1 MAKING THE MOST OF THE TYPE SYSTEM	1
The Value of Good Names	2
Adding Clarity Through Types	4
Named Arguments	4
Custom Types	5
Encapsulation	6
Immutability	7
Value Validation	8
Testing	9
Refactoring	9
Replacing Magic Numbers with Named Constants	10
Simplifying Properties and Values	11
Overloading Arithmetic Operators	14
Determining a Need for New Types	15
Encoding Units	18
Itemizing Units with enums	19
Static Creation Methods	22
Symmetry in Design	23
Making Units Explicit	24
Choosing the Most Natural Usage	25
Returning Types Implied by Units	27
A Fully Formed Encapsulated Value	28
Deciding Whether to Abstract Types	29
Summary	30
2 VALUE AND REFERENCE TYPES	31
User-Defined Types	32
Structs and Classes	32
Records and Record Structs	33
Inheritance	34
Type Instance Lifetimes	36
Variables	37
Variables vs. Values	38
Definite Assignment	39

Instances and Storage	39
Embedded Values	40
Boxed Values	44
Semantics and Type	45
The Common Type System	45
Copy Semantics	46
Records, Structs, and Value Semantics	48
Construction and Initialization	49
Default Initialization	50
Instance Constructors	51
Field Initializers	58
Object Initializers	58
null Values and Default Values	60
Generics and null	61
Generics and Default Values	62
Nullable Value Types	63
Nullable Reference Types	64
The Null-Forgiving Operator	66
Summary	67

3 REFERENCE AND VALUE PARAMETERS 69

Method Parameters and Arguments	70
Reference Types vs. By-Reference Parameters	70
Value Types and Parameters	71
The Value of a Reference	73
Reference Variables and Aliasing	74
Mutable By-Reference Parameters	76
Passing References by Reference	77
Passing Values by Reference	78
Working with Output Parameters	79
Limitations of By-Reference Parameters	82
Property Values	82
Overloading on By-Reference Parameters	83
Using Fields	84
Extension Methods	87
Side Effects and Direct Effects	88
Mutation vs. Creation	89
Declarative Code and Performance	91
Read-Only References and Returning by Reference	92
Returning Values by Reference	94
Preventing Modifications to Data	95
Keeping By-Reference Variables Within Scope	97
Considering Performance vs. Simplicity	101
Final Word on Mutable By-Reference Parameters	102
Summary	103

4**IMPLICIT AND EXPLICIT COPYING****105**

Copying by Simple Assignment	106
Value Copy Behavior	107
Read-Only Properties vs. Immutable Types	109
Creating New Objects	110
Overwriting a Value	111
Constructing Value Types	112
Copying Records Like Value Types	114
Identifying Unnecessary Boxing	115
To an Interface	116
In Method Calls	117
Method Parameters and Arguments	118
Passing and Returning by Value	119
Accessing Properties	120
Using Expressions with Operators	121
Modifying Return Type Instances	123
Reference Type Properties	125
Instance Methods and Mutability	126
Properties as Arguments for Read-Only Parameters	127
Defensive Copies	128
Mutable Value Types and in Parameters	129
Automatic vs. Nonautomatic Properties	130
Read-Only Reference Variables	131
Read-Only Fields	132
Defending Against Mutation	133
Read-Only Accessors and Methods	134
Read-Only Types	135
Summary	136

5**TYPES OF EQUALITY****139**

Built-in Equality	140
Whole Numbers	140
Floating-Point Values	141
Reference Equality	145
Strings and Value Equality	148
Custom Equality for Classes	149
Defining Equality Operators	150
Handling Comparisons with null	151
Making Type-Safe Comparisons	152
Working with Hash Codes	152
Structs and Equality	156
Overriding Equals for Structs	156
Boxing Values and Comparing by Identity	158
Comparing Generic Variables	162
Generic Code and the Equals Method	163
The <code>IEquatable<T></code> Interface	164

Compiler-Generated Equality	165
Records and Record Structs	165
Equality for Nullable Values	168
Value Tuples and Equality	170
Summary	172

6 THE NATURE OF VALUES 175

Value vs. Reference Semantics	176
Copying and Equality Comparison Behavior	177
Mutability	181
Mechanics vs. Semantics	182
Object Relationships	183
Kinds of Objects	184
Object Characteristics	185
Design Refinement to Model Object Roles	191
Abstraction and Vocabulary	191
Encapsulation and Cohesion	192
Eliminating Duplication	193
Establishing Class Invariants	194
Clarifying with Symmetry	196
Encapsulation and the Public Interface	196
Extending the Interface	197
Reducing the Internal Interface	198
Composing Abstractions	199
Choosing Between Value and Reference Semantics	199
Avoiding the Pitfalls of Default Variables	200
Implementing Custom vs. Generated Behavior	201
Overriding Generated Methods	202
Comparison for Ordering	203
Equivalence vs. Equality	204
The Contract for Comparisons	205
Other Kinds of Ordering	206
The Perils of Uniformity and Consistency	207
Arithmetic and Nonarithmetic Types	208
Nonstandard Operator Behavior	209
Summary	209

7 VALUE TYPES AND POLYMORPHISM 211

Why Value Types Are Sealed	212
Implementation Inheritance	213
Value-Based Equality for Classes	214
Equality Behavior in Derived Classes	218
Equality Comparisons and Type Substitution	220
Inclusion Polymorphism and Subtyping	222
Working with Input and Output Types of Virtual Methods	223
Upholding a Type's Contract	224
Inheriting Record Types	225
Avoiding Implementation Inheritance	230
Containing Instead of Inheriting Types	231

Parametric Polymorphism with Generics	233
Generic Constraints and Protocol Interfaces	233
Generic Method Parameters and Type Deduction	236
Parameterized Types	237
Ad Hoc Polymorphism with Overloading	238
Symbolic Polymorphism with Overloaded Operators	240
Generic Delegates for Polymorphism	241
Coercion Polymorphism Using Conversions	242
Widening vs. Narrowing Conversions	244
For Representation	244
For Purpose	245
Summary	247

8 PERFORMANCE AND EFFICIENCY 249

Measuring and Optimizing Performance	250
The JIT Compiler	250
Performance Benchmarks	251
The Profiler	252
Measuring Basic Performance with Equals	253
Hidden Costs of Simplicity	255
The ValueType.Equals Method	257
The ValueType.GetHashCode Method	259
The GetHashCode.Combine Method	259
Optimizing Equality	261
The Effect of IEquatable<T>	263
Property Accesses	265
The Equality Operators	266
How Type Affects Performance	270
Measuring the Cost of Copying	270
Copying Large Instances	272
Weighing Object Construction Costs	273
Measuring the Compiler-Generated Equals Method	277
How Common Idioms and Practices Affect Performance	279
Looping and Iteration	279
Pattern Matching and Selection	284
Summary	286

AFTERWORD 287

APPENDIX: FURTHER READING 289

INDEX 301