Data Structures and Algorithms with Go

Create efficient solutions and optimize your Go coding skills

Dušan Stojanović

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Dedicated to

My beloved brother:

Nikola Stojanović

About the Author

Dušan Stojanović was born on May 27, 1989 in Smederevo, Serbia and raised in Baničina. He attended the University of Belgrade and received a Master's degree in computer science in 2013. Since then, he has been working in software development, playing central roles in numerous projects, such as user administration, online school platforms, e-commerce solutions, video-streaming platforms, and advertising solutions as a software engineer. His first book, Building Server-side and Microservices with Go was published in 2021. Furthermore, he has published and written several technical articles on microservice development with Go and related topics. Currently, he lives in Belgrade (Serbia), working as a senior software developer.

About the Reviewer

Mahima Singla is a passionate Principal Software Design Engineer with extensive professional experience and passion for designing and implementing robust, scalable software solutions in the domain of cloud assessment, cloud governance, cloud cost optimization, application fitment for cloud, cloud operating model, cutting-edge technologies, particularly in the realms of cloud computing, AWS, and Kubernetes in Go language.

She is currently working in Precisely Software and is part of the Studio Administrator Cloud project and Customer Onboarding project. She has played a pivotal role in architecting and developing solutions that harness the full potential of cloud platforms. She has proficiency in AWS, including services like AWS services EC2, S3, Lambda, has allowed her to create resilient and scalable applications that align with business objectives.

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Throughout the career, she has not only focused on technical excellence but also on driving innovation and fostering collaborative environments. Mahima takes pride in leading teams to deliver high-quality solutions that meet and exceed client expectations. She is dedicated to staying abreast of industry trends, and leveraging the latest technologies has allowed her to contribute meaningfully to the success of the projects she undertakes.

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Preface

Building a modern software solution can be a complex task that requires a comprehensive understanding of the latest technologies and the core of the problem. Knowing which data structure to use or some algorithm that can save resources and increase the solution's performance becomes essential. In addition, programming languages like Go are powerful tools that have become increasingly popular in software development.

This book is designed to provide a comprehensive guide for the most common data structures and the algorithms that can be executed on them. Everything will be followed with implementation in the Go programming language. Go's standard library offers completed implementations for some data structures (and algorithms). For others, everything will be developed from scratch. Numerous practical examples and illustrations will be provided to help you understand the concepts explained in each chapter.

This book is intended for developers familiar with the Go programming language who want to learn how to use it to implement algorithms. It is also helpful for developers who want to expand or refresh their knowledge of data structures and algorithms and improve their skills in building software solutions.

With this book, you will gain the knowledge and skills to become a proficient developer and recognize which data structure (or algorithm) suits a specific problem. I hope you will find this book informative and helpful.

Chapter 1: Fundamentals of Data Structures and Algorithms – This chapter introduces the reader to the concepts of data structures and algorithms. Some of the fundamentals that will be explained are characteristics of data structures, how data structures are represented in memory, how algorithms can be described, and how algorithms can be categorized. Furthermore, the chapter also gives a short history of algorithms and explains how algorithms and data structures are connected.

Chapter 2: Arrays and Algorithms for Searching and Sorting – This chapter presents a detailed overview of arrays (and slices as special types of arrays) and basic array operations. Furthermore, sorting and searching algorithms

will be shown, with detailed implementations and comparisons. This chapter will also tackle the subject of multidimensional arrays.

Chapter 3: Lists – This chapter covers lists and basic operations that can be performed on them. Explain the differences between types of lists, how lists are different from arrays, and how each list type can be implemented.

Chapter 4: Stack and Queue – This chapter introduces the reader to two linear data structures, stack and queue, that work on similar principles (there is an order in which elements are inserted and removed), demonstrating how to implement them. Besides regular queues, priority queues will be presented.

Chapter 5: Hashing and Maps – This chapter gives special attention to maps as one of the most popular data structures and the operations supported by them. This chapter also shows how to use maps in the Go programming language and explains the concept of hashing.

Chapter 6: Trees and Traversal Algorithms – This chapter covers all tree-related topics, like types of trees, usages, and basic operations. The second part of the chapter will present and compare different traversal algorithms. Ultimately, the method of sorting an array with a tree will be shown.

Chapter 7: Graphs and Traversal Algorithms – This chapter introduces the fundamental concepts of graphs, with all operations that can be performed on them. This chapter also explains different traversal algorithms with details and numerous practical examples. The second part of the chapter explains what a spanning tree is, how to find the shortest part between nodes, how to calculate flow in graphs, and how to find the critical path.

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Chapter 1
Fundamentals of Data Structures and Algorithms

Introduction

This chapter will introduce the general concepts related to data structures and algorithms. We will start by explaining some characteristics of data structures. After that, we will present a short history of algorithms, explain how to classify them and introduce O-notation. Near the end, the concept of functions in the Go programming language will be presented. This chapter will also explain the connection between algorithms and data structures.

Structure

The chapter covers the following topics:

- Fundamentals of data structures
- Characteristics of data structures
- Memory representation
- Structures in Go
- History of algorithms
- Fundamentals of algorithms

- Representation of algorithms
- Classification of algorithms
- Algorithmic complexity and O-notation
- Functions in Go
- Data structures and algorithms

Objectives

By the end of this chapter, you will be able to understand the basic concepts of data structures and algorithms. This is a perfect starting point for implementing and solving many software problems. Structures and algorithms described in this book are often more complex than ones we will encounter in practical solutions.

Fundamentals of data structures

The data structure is a description of data organization. For example, a data structure representing a point in two-dimensional space should contain two values, each representing coordinates (x and y). Another example can be a structure that defines an address. That structure can contain information about street names, street numbers, cities, postal codes, and so on.

We have complete freedom to create data structures that best suit our needs. Later in this chapter, we will see how to use concepts of Go programming language to define desired data structure.

Besides these custom structures, there are a lot of well-known and established data structures, like arrays, graphs, maps, and so on. Through this book, we will get familiar with all of them.

On each data structure, operations specific to the given data structure can be performed. For example, we can perform a sort operation on an array. This operation will sort array elements in the desired order. For each structure we will cover in this book, we will explain the basic operations that can be performed.

Characteristics of data structures

We have multiple data structures, but we can use some characteristics to classify them. In this section will present some of the most common characteristics and related classifications.