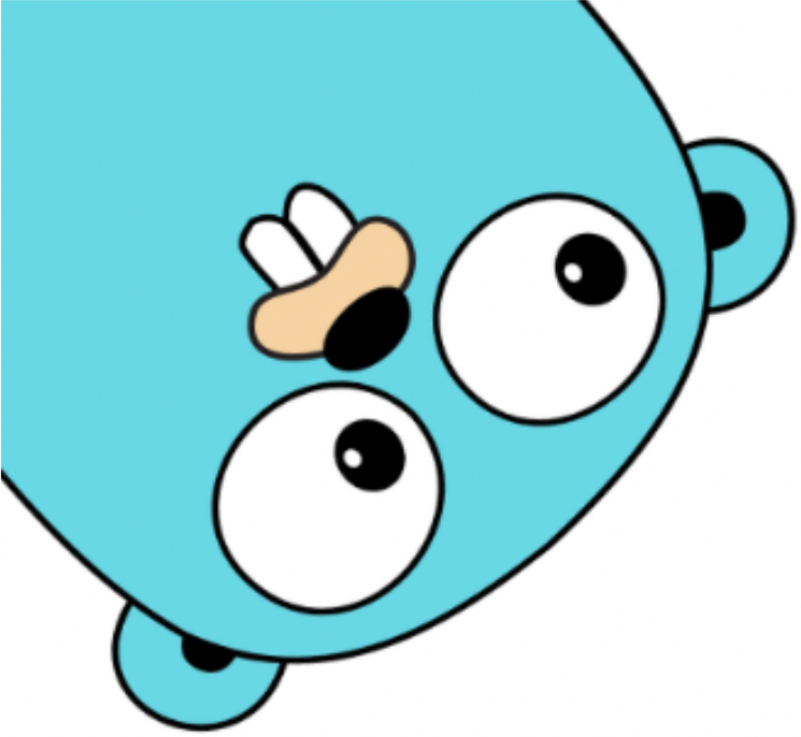

LEARN GO

Master the fundamentals and advanced features of the Go programming language

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Preface

Welcome, I'm glad you're here! Go combines the efficacy, speed, and safety of a compiled language with the ease of programming of a dynamic language to make programming more fun again. The objective of this book is to help you master the fundamentals and advanced features of the Go programming language.

Thank you for checking out this book, I hope it provides a positive learning experience.

License

What is Go?

Go (also known as *Golang*) is a programming language developed at Google in 2007 and open-sourced in 2009.

It focuses on simplicity, reliability, and efficiency. It was designed to combine the efficacy, speed, and safety of a statically typed and compiled language with the ease of programming of a dynamic language to make programming more fun again.

In a way, they wanted to combine the best parts of Python and C++ so that they can build reliable systems that can take advantage of multi-core processors.

Why learn Go?

Before we start this course, let us talk about why we should learn Go.

1. Easy to learn

Go is quite easy to learn and has a supportive and active community.

And being a multipurpose language you can use it for things like backend development, cloud computing, and more recently, data science.

2. Fast and Reliable

Which makes it highly suitable for distributed systems. Projects such as Kubernetes and Docker are written in Go.

3. Simple yet powerful

Go has just 25 keywords which makes it easy to read, write and maintain. The language itself is concise.

But don't be fooled by the simplicity, Go has several powerful features that we will later learn in the course.

4. Career opportunities

Go is growing fast and is being adopted by companies of any size. and with that, comes new high-paying job opportunities.

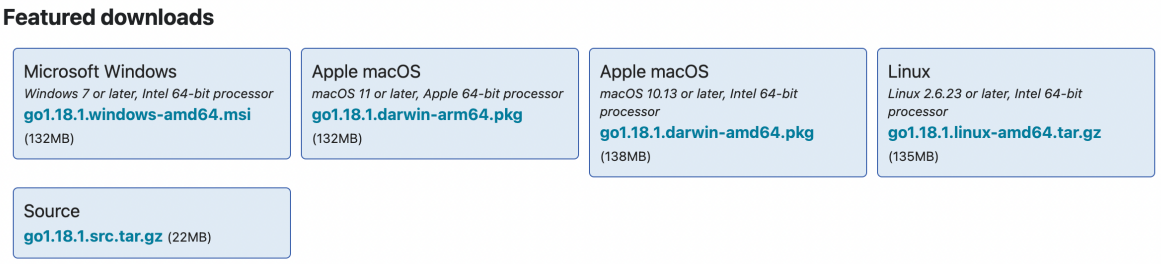
I hope this made you excited about Go. Let's start this course.

Installation and Setup

In this tutorial, we will install Go and setup our code editor.

Download

We can install Go from the downloads section.



Installation

These instructions are from the official website.

MacOS

Open the package file you downloaded and follow the prompts to install Go. The package installs the Go distribution to `/usr/local/go`. The package should put the `/usr/local/go/bin` directory in your `PATH` environment variable. You may need to restart any open Terminal sessions for the change to take effect.

Verify that you've installed Go by opening a command prompt and typing the following command:

```
$ go version
```

Confirm that the command prints the installed version of Go.

Linux

1. Remove any previous Go installation by deleting the `/usr/local/go` folder (if it exists), then extract the archive you just downloaded into `/usr/local`, creating a fresh Go tree in `/usr/local/go`:

```
$ rm -rf /usr/local/go && tar -C /usr/local -xzf
go1.18.1.linux-amd64.tar.gz
```

Note: You may need to run the command as root or through sudo.

Do not untar the archive into an existing `/usr/local/go` tree. This is known to produce broken Go installations.

2. Add `/usr/local/go/bin` to the `PATH` environment variable. You can do this by adding the following line to your `$HOME/.profile` or `/etc/profile` (for a system-wide installation):

```
export PATH=$PATH:/usr/local/go/bin
```

Note: Changes made to a profile file may not apply until the next time you log into your computer. To apply the changes immediately, just run the shell commands directly or execute them from the profile using a command such as source `$HOME/.profile`.

3. Verify that you've installed Go by opening a command prompt and typing the following command:

```
$ go version
```

4. Confirm that the command prints the installed version of Go.

Windows

1. Open the MSI file you downloaded and follow the prompts to install Go.

By default, the installer will install Go to Program Files or Program Files (x86). You can change the location as needed. After installing, you will need to close and reopen any open command prompts so that changes to the environment made by the installer are reflected at the command prompt.

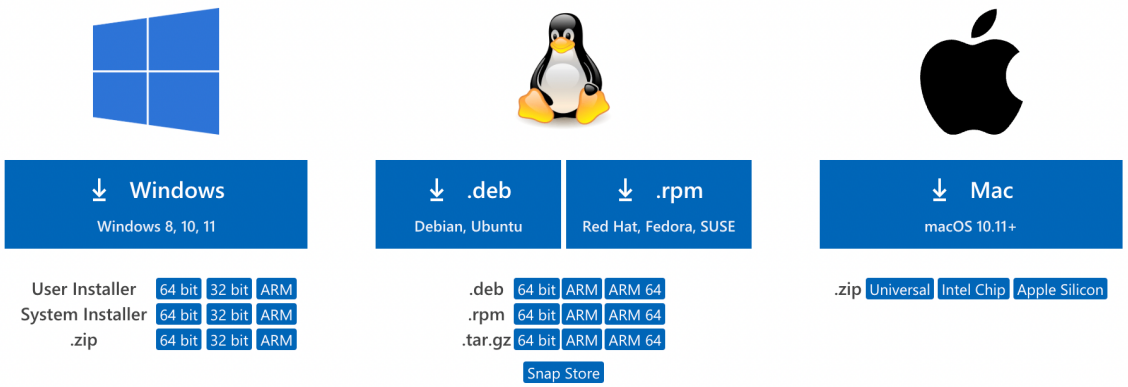
2. Verify that you've installed Go.
    1. In Windows, click the Start menu.
    2. In the menu's search box, type cmd, then press the Enter key.
    3. In the Command Prompt window that appears, type the following command:

```
$ go version
```

3. Confirm that the command prints the installed version of Go.

VS Code

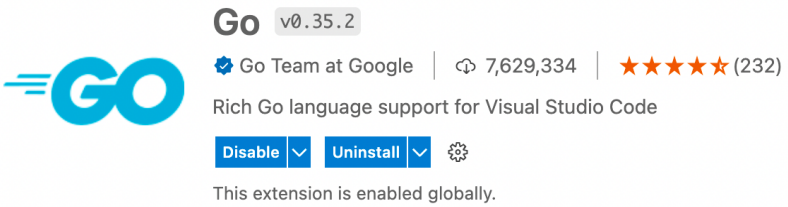
In this course, I will be using VS Code and you can download it from here.



Feel free to use any other code editor you prefer.

Extension

Make sure to also install the Go extension which makes it easier to work with Go in VS Code.



This is it for the installation and setup of Go, let's start the course and write our first hello world!

Hello World

Let's write our first hello world program, we can start by initializing a module. For that, we can use the `go mod` command.

```
$ go mod init example
```

But wait...what's a `module`? Don't worry we will discuss that soon! But for now, assume that the module is basically a collection of Go packages.

Moving ahead, let's now create a `main.go` file and write a program that simply prints hello world.

```
package main

import "fmt"

func main() {
      fmt.Println("Hello World!")
}
```

If you're wondering, `fmt` is part of the Go standard library which is a set of core packages provided by the language.

Structure of a Go program

Now, let's quickly break down what we did here, or rather the structure of a Go program.

First, we defined a package such as `main`.

```
package main
```

Then, we have some imports.

```
import "fmt"
```

Last but not least, is our `main` function which acts as an entry point for our application, just like in other languages like C, Java, or C#.

```
func main() {
      ...
}
```

Remember, the goal here is to keep a mental note, and later in the course, we'll learn about `functions`, `imports`, and other things in detail!

Finally, to run our code, we can simply use `go run` command.

```
$ go run main.go
Hello World!
```

Congratulations, you just wrote your first Go program!

Variables and Data Types

In this tutorial, we will learn about variables. We will also learn about the different data types that Go provides us.

Variables

Let's start with declaring a variable.

This is also known as declaration without initialization:

```
var foo string
```

Declaration with initialization:

```
var foo string = "Go is awesome"
```

Multiple declarations:

```
var foo, bar string = "Hello", "World"
// OR
var (
      foo string = "Hello"
      bar string  = "World"
)
```

Type is omitted but will be inferred:

```
var foo = "What's my type?"
```

Shorthand declaration, here we omit `var` keyword and type is always implicit. This is how we will see variables being declared most of the time. We also use the `:=` for declaration plus assignment.

```
foo := "Shorthand!"
```

Note: Shorthand only works inside `function` bodies.

Constants

We can also declare constants with the `const` keyword. Which as the name suggests, are fixed values that cannot be reassigned.

```
const constant = "This is a constant"
```

It is also important to note that, only constants can be assigned to other constants.

```
const a = 10
const b = a // ✅ Works

var a = 10
const b = a // ❌ a (variable of type int) is not constant
(InvalidConstInit)
```

Data Types

Perfect! Now let's look at some basic data types available in Go. Starting with string.

String

In Go, a string is a sequence of bytes. They are declared either using double quotes or backticks which can span multiple lines.

```
var name string = "My name is Go"

var bio string = `I am statically typed.
                                    I was designed at Google.`
```

Bool

Next is `bool` which is used to store boolean values. It can have two possible values - `true` or `false`.

```
var value bool = false
var isItTrue bool = true
```

Operators

We can use the following operators on boolean types

Type	Syntax
Logical	&& || !
Equality	== !=

Numeric types

Now, let's talk about numeric types.

Signed and Unsigned integers

Go has several built-in integer types of varying sizes for storing signed and unsigned integers

The size of the generic `int` and `uint` types are platform-dependent. This means it is 32-bits wide on a 32-bit system and 64-bits wide on a 64-bit system.

```
var i int = 404                     // Platform dependent
var i8 int8 = 127                   // -128 to 127
var i16 int16 = 32767               // -2^15 to 2^15 - 1
var i32 int32 = -2147483647         // -2^31 to 2^31 - 1
var i64 int64 = 9223372036854775807 // -2^63 to 2^63 - 1
```

Similar to signed integers, we have unsigned integers.

```
var ui uint = 404                     // Platform dependent
var ui8 uint8 = 255                   // 0 to 255
var ui16 uint16 = 65535               // 0 to 2^16
var ui32 uint32 = 2147483647          // 0 to 2^32
var ui64 uint64 = 9223372036854775807 // 0 to 2^64
var uiptr uintptr                     // Integer representation of
a memory address
```

If you noticed, there's also an unsigned integer pointer `uintptr` type, which is an integer representation of a memory address. It is not recommended to use this, so we don't have to worry about it.

So which one should we use?

It is recommended that whenever we need an integer value, we should just use `int` unless we have a specific reason to use a sized or unsigned integer type.

Byte and Rune

Golang has two additional integer types called `byte` and `rune` that are aliases for `uint8` and `int32` data types respectively.

```
type byte = uint8
type rune = int32
```

A `rune` represents a unicode code point.

```
var b byte = 'a'
var r rune = '🍕'
```

Floating point

Next, we have floating point types which are used to store numbers with a decimal component.

Go has two floating point types `float32` and `float64`. Both type follows the IEEE-754 standard.

The default type for floating point values is float64.

```
var f32 float32 = 1.7812 // IEEE-754 32-bit
var f64 float64 = 3.1415 // IEEE-754 64-bit
```

Operators

Go provides several operators for performing operations on numeric types.

Type	Syntax
Arithmetic	`+ - * / %`
Comparison	`== != < > <= >=`
Bitwise	`& | ^ << >>`
Increment/Decrement	`++ --`
Assignment	`= += -= *= /= %= <<= >>= &= |= ^=`

Complex

There are 2 complex types in Go, `complex128` where both real and imaginary parts are `float64` and `complex64` where real and imaginary parts are `float32`.

We can define complex numbers either using the built-in complex function or as literals.

```
var c1 complex128 = complex(10, 1)
var c2 complex64 = 12 + 4i
```

Zero Values

Now let's discuss zero values. So in Go, any variable declared without an explicit initial value is given its *zero value*. For example, let's declare some variables and see:

```
var i int
var f float64
var b bool
var s string

fmt.Printf("%v %v %v %q\n", i, f, b, s)
```

```
$ go run main.go
0 0 false ""
```

So, as we can see `int` and `float` are assigned as 0, `bool` as false, and string as an empty `string`. This is quite different from how other languages do it. For example, most languages initialize unassigned variables as null or undefined.

This is great, but what are those percent symbols in our `Printf` function? As you've already guessed, they are used for formatting and we will learn about them later.

Type Conversion

Moving on, now that we have seen how data types work, let's see how to do type conversion.

```
i := 42
f := float64(i)
u := uint(f)

fmt.Printf("%T %T", f, u)
```

```
$ go run main.go
float64 uint
```

And as we can see, it prints the type as float64 and uint.

Note that this is different from parsing.

Alias types

Alias types were introduced in Go 1.9. They allow developers to provide an alternate name for an existing type and use it interchangeably with the underlying type.

```
package main

import "fmt"

type MyAlias = string

func main() {
      var str MyAlias = "I am an alias"

      fmt.Printf("%T - %s", str, str) // Output: string - I am an
alias
}
```

Defined types

Lastly, we have defined types that unlike alias types do not use an equals sign.

```
package main

import "fmt"

type MyDefined string

func main() {
      var str MyDefined = "I am defined"

      fmt.Printf("%T - %s", str, str) // Output: main.MyDefined - I
am defined
}
```

But wait...what's the difference?

So, defined types do more than just give a name to a type.

It first defines a new named type with an underlying type. However, this defined type is different from any other type, including its underline type.

Hence, it cannot be used interchangeably with the underlying type like alias types.

It's a bit confusing at first, hopefully, this example will make things clear.

```
package main

import "fmt"

type MyAlias = string

type MyDefined string

func main() {
```

```
	var alias MyAlias
	var def MyDefined

	// ✅ Works
	var copy1 string = alias

	// ❌ Cannot use def (variable of type MyDefined) as string
value in variable
	var copy2 string = def

	fmt.Println(copy1, copy2)
}
```

As we can see, we cannot use the defined type interchangeably with the underlying type, unlike *alias types*.

String Formatting

In this tutorial, we will learn about string formatting or sometimes also known as templating.

`fmt` package contains lots of functions. So to save time, we will discuss the most frequently used functions. Let's start with `fmt.Print` inside our main function.

```
...

fmt.Print("What", "is", "your", "name?")
fmt.Print("My", "name", "is", "golang")
...
```

```
$ go run main.go
Whatisyourname?Mynameisgolang
```

As we can see, `Print` does not format anything, it simply takes a string and prints it.

Next, we have `Println` which is the same as Print but it adds a new line at the end and also inserts space between the arguments.

```
...

fmt.Println("What", "is", "your", "name?")
fmt.Println("My", "name", "is", "golang")
...
```

```
$ go run main.go
What is your name?
My name is golang
```

That's much better!

Next, we have `Printf` also known as *"Print Formatter"*, which allows us to format numbers, strings, booleans, and much more.

Let's look at an example.

```
...
name := "golang"

fmt.Println("What is your name?")
fmt.Printf("My name is %s", name)
...
```

```
$ go run main.go
What is your name?
My name is golang
```

As we can see that `%s` was substituted with our `name` variable.

But the question is what is `%s` and what does it mean?

So, these are called *annotation* verbs and they tell the function how to format the arguments. We can control things like width, types, and precision with these and there are lots of them. Here's a cheatsheet.

Now, let's quickly look at some more examples. Here we will try to calculate a percentage and print it to the console.

```
...
percent := (7.0 / 9) * 100
fmt.Printf("%f", percent)
...
```

```
$ go run main.go
77.777778
```

Let's say we want just `77.78` which is 2 points precision, we can do that as well by using `.2f`.

Also, to add an actual percent sign, we will need to escape it.

```
...
percent := (7.0 / 9) * 100
fmt.Printf("%.2f %%", percent)
...
```

```
$ go run main.go
77.78 %
```

This brings us to `Sprint`, `Sprintln`, and `Sprintf`. These are basically the same as the print functions, the only difference being they return the string instead of printing it.

Let's take a look at an example.

```
...
s := fmt.Sprintf("hex:%x bin:%b", 10 ,10)
fmt.Println(s)
...
```

```
$ go run main.go
hex:a bin:1010
```

So, as we can see `Sprintf` formats our integer as hex or binary and returns it as a string.

Lastly, we have multiline string literals, which can be used like this.

```
...
msg := `
Hello from
multiline
`

fmt.Println(msg)
...
```

Great! But this is just the tip of the iceberg...so make sure to check out the go doc for `fmt` package.

For those who are coming from C/C++ background, this should feel natural, but if you're coming from, let's say Python or JavaScript, this might be a little strange at first. But it is very powerful and you'll see this functionality used quite extensively.

Flow Control

Let's talk about flow control, starting with if/else.

If/Else

This works pretty much the same as you expect but the expression doesn't need to be surrounded by parentheses `()`.

```
func main() {
	x := 10

	if x > 5 {
		fmt.Println("x is gt 5")
	} else if x > 10 {
		fmt.Println("x is gt 10")
	} else {
		fmt.Println("else case")
	}
}
```

```
$ go run main.go
x is gt 5
```

Compact if

We can also compact our if statements.

```
func main() {
	if x := 10; x > 5 {
		fmt.Println("x is gt 5")
	}
}
```

Note: This pattern is quite common.

Switch

Next, we have `switch` statement, which is often a shorter way to write conditional logic.

In Go, the switch case only runs the first case whose value is equal to the condition expression and not all the cases that follow. Hence, unlike other languages, `break` statement is automatically added at the end of each case.

This means that it evaluates cases from top to bottom, stopping when a case succeeds. Let's take a look at an example:

```
func main() {
	day := "monday"

	switch day {
	case "monday":
		fmt.Println("time to work!")
	case "friday":
		fmt.Println("let's party")
	default:
		fmt.Println("browse memes")
	}
}
```

```
$ go run main.go
time to work!
```

Switch also supports shorthand declaration like this.

```
switch day := "monday"; day {
	case "monday":
		fmt.Println("time to work!")
	case "friday":
		fmt.Println("let's party")
	default:
		fmt.Println("browse memes")
	}
```

We can also use the `fallthrough` keyword to transfer control to the next case even though the current case might have matched.

```
switch day := "monday"; day {
      case "monday":
            fmt.Println("time to work!")
            fallthrough
      case "friday":
            fmt.Println("let's party")
      default:
            fmt.Println("browse memes")
      }
```

And if we run this, we'll see that after the first case matches the switch statement continues to the next case because of the `fallthrough` keyword.

```
$ go run main.go
time to work!
let's party
```

We can also use it without any condition, which is the same as `switch true`.

```
x := 10

switch {
      case x > 5:
            fmt.Println("x is greater")
      default:
            fmt.Println("x is not greater")
}
```

Loops

Now, let's turn our attention toward loops.

So in Go, we only have one type of loop which is the `for` loop.

But it's incredibly versatile. Same as if statement, for loop, doesn't need any parenthesis `()` unlike other languages.

For loop

Let's start with the basic `for` loop.

```
func main() {
	for i := 0; i < 10; i++ {
		fmt.Println(i)
	}
}
```

The basic `for` loop has three components separated by semicolons:

- **init statement**: which is executed before the first iteration.
- **condition expression**: which is evaluated before every iteration.
- **post statement**: which is executed at the end of every iteration.

Break and continue

As expected, Go also supports both `break` and `continue` statements for loop control. Let's try a quick example:

```
func main() {
	for i := 0; i < 10; i++ {
		if i < 2 {
			continue
		}

		fmt.Println(i)

		if i > 5 {
			break
		}
	}

	fmt.Println("We broke out!")
}
```

So, the `continue` statement is used when we want to skip the remaining portion of the loop, and `break` statement is used when we want to break out of the loop.

Also, Init and post statements are optional, hence we can make our `for` loop behave like a while loop as well.

```
func main() {
      i := 0

      for ;i < 10; {
            i += 1
      }
}
```

Note: we can also remove the additional semi-colons to make it a little cleaner.

Forever loop

Lastly, If we omit the loop condition, it loops forever, so an infinite loop can be compactly expressed. This is also known as the forever loop.

```
func main() {
      for {
            // do stuff here
      }
}
```

Functions

In this tutorial, we will discuss how we work with functions in Go. So, let's start with a simple function declaration.

Simple declaration

```
func myFunction() {}
```

And we can *call or execute* it as follows.

```
...
myFunction()
...
```

Let's pass some parameters to it.

```
func main() {
      myFunction("Hello")
}

func myFunction(p1 string) {
      fmt.Println(p1)
}
```

```
$ go run main.go
```

As we can see it prints our message. We can also do a shorthand declaration if the consecutive parameters have the same type. For example:

```
func myNextFunction(p1, p2 string) {}
```

Returning the value

Now let's also return a value.

```
func main() {
	s := myFunction("Hello")
	fmt.Println(s)
}

func myFunction(p1 string) string {
	msg := fmt.Sprintf("%s function", p1)
	return msg
}
```

Multiple returns

Why return one value at a time, when we can do more? Go also supports multiple returns!

```
func main() {
	s, i := myFunction("Hello")
	fmt.Println(s, i)
}

func myFunction(p1 string) (string, int) {
	msg := fmt.Sprintf("%s function", p1)
	return msg, 10
}
```

Named returns

Another cool feature is named returns, where return values can be named and treated as their own variables.

```
func myFunction(p1 string) (s string, i int) {
	s = fmt.Sprintf("%s function", p1)
	i = 10

	return
}
```

Notice how we added a `return` statement without any arguments, this is also known as *naked return*.
I will say that, although this feature is interesting, please use it with care as this might reduce readability for larger functions.

Functions as values

Next, let's talk about functions as values, in Go functions are first class and we can use them as values. So, let's clean up our function and try it out!

```
func myFunction() {
	fn := func() {
		fmt.Println("inside fn")
	}

	fn()
}
```

We can also simplify this by making `fn` an *anonymous function*.

```
func myFunction() {
	func() {
		fmt.Println("inside fn")
	}()
}
```

Notice how we execute it using the parenthesis at the end.

Closures

Why stop there? let's also return a function and hence create something called a closure. A simple definition can be that a closure is a function value that references variables from outside its body.

Closures are lexically scoped, which means functions can access the values in scope when defining the function.

```
func myFunction() func(int) int {
	sum := 0

	return func(v int) int {
		sum += v

		return sum
	}
}
```

```
...
add := myFunction()

add(5)
fmt.Println(add(10))
...
```

As we can see, we get a result of 15 as `sum` variable is *bound* to the function. This is a very powerful concept and definitely, a must know.

Variadic Functions

Now let's look at variadic functions, which are functions that can take zero or multiple arguments using the `...` ellipses operator.

An example here would be a function that can add a bunch of values.

```
func main() {
	sum := add(1, 2, 3, 5)
	fmt.Println(sum)
}

func add(values ...int) int {
	sum := 0

	for _, v := range values {
		sum += v
	}

	return sum
}
```

Pretty cool huh? Also, don't worry about the `range` keyword, we will discuss it later in the course.

***Fun fact**: `fmt.Println` is a variadic function, that's how we were able to pass multiple values to it.*

Init

In Go, `init` is a special lifecycle function that is executed before the `main` function.

Similar to `main`, the `init` function does not take any arguments nor returns any value. Let's see how it works with an example.

```
package main

import "fmt"

func init() {
      fmt.Println("Before main!")
}

func main() {
      fmt.Println("Running main")
}
```

As expected, the `init` function was executed before the `main` function.

```
$ go run main.go
Before main!
Running main
```

Unlike `main`, there can be more than one `init` function in single or multiple files.

For multiple `init` in a single file, their processing is done in the order of their declaration, while `init` functions declared in multiple files are processed according to the lexicographic filename order.

```
package main

import "fmt"

func init() {
      fmt.Println("Before main!")
}

func init() {
      fmt.Println("Hello again?")
}

func main() {
      fmt.Println("Running main")
}
```

And if we run this, we'll see the `init` functions were executed in the order they were declared.

```
$ go run main.go
Before main!
Hello again?
Running main
```

The `init` function is optional and is particularly used for any global setup which might be essential for our program, such as establishing a database connection, fetching configuration files, setting up environment variables, etc.

Defer

Lastly, let's discuss the `defer` keyword, which lets us postpones the execution of a function until the surrounding function returns.

```
func main() {
      defer fmt.Println("I am finished")
      fmt.Println("Doing some work...")
}
```

Can we use multiple defer functions? Absolutely, this brings us to what is known as *defer stack*. Let's take a look at an example:

```
func main() {
      defer fmt.Println("I am finished")
      defer fmt.Println("Are you?")

      fmt.Println("Doing some work...")
}
```

```
$ go run main.go
Doing some work...
Are you?
I am finished
```

As we can see, defer statements are stacked and executed in a *last in first out* manner.

So, Defer is incredibly useful and is commonly used for doing cleanup or error handling.

Functions can also be used with generics but we will discuss them later in the course.

Modules

In this tutorial, we will learn about modules.

What are modules?

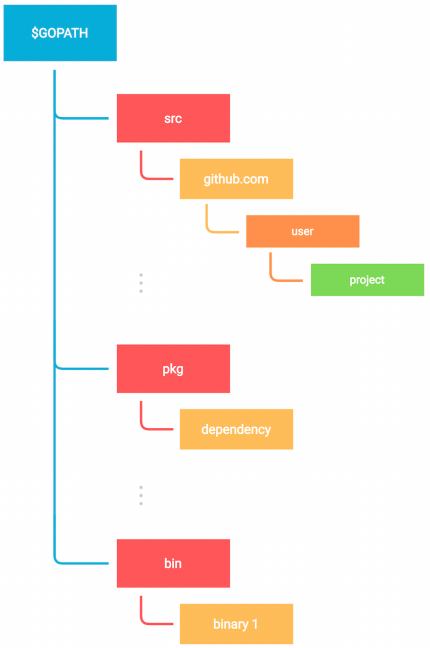
Simply defined, A module is a collection of Go packages stored in a file tree with a `go.mod` file at its root, provided the directory is *outside* `$GOPATH/src`.

Go modules were introduced in Go 1.11, which brings native support for versions and modules. Earlier, we needed the `GO111MODULE=on` flag to turn on the modules functionality when it was experimental. But now after Go 1.13 modules mode is the default for all development.

But wait, what is `GOPATH`?

Well, `GOPATH` is a variable that defines the root of your workspace and it contains the following folders:

- **src**: contains Go source code organized in a hierarchy.
- **pkg**: contains compiled package code.
- **bin**: contains compiled binaries and executables.



Like earlier, let's create a new module using `go mod init` command which creates a new module and initializes the `go.mod` file that describes it.

```
$ go mod init example
```

The important thing to note here is that a Go module can correspond to a Github repository as well if you plan to publish this module. For example:

```
$ go mod init example
```

Now, let's explore `go.mod` which is the file that defines the module's *module path* and also the *import path* used for the root directory, and its *dependency requirements*.

```
module <name>

go <version>

require (
      ...
)
```

And if we want to add a new dependency, we will use `go install` command:

```
$ go install github.com/rs/zerolog
```

As we can see a `go.sum` file was also created. This file contains the expected hashes of the content of the new modules.

We can list all the dependencies using go list command as follows:

```
$ go list -m all
```

If the dependency is not used, we can simply remove it using `go mod tidy` command:

```
$ go mod tidy
```

Finishing up our discussion on modules, let's also discuss vendoring.

Vendoring is the act of making your own copy of the 3rd party packages your project is using. Those copies are traditionally placed inside each project and then saved in the project repository.

This can be done through `go mod vendor` command.

So, let's reinstall the removed module using `go mod tidy`.

```
package main

import "github.com/rs/zerolog/log"

func main() {
      log.Info().Msg("Hello")
}
```

```
$ go mod tidy
go: finding module for package github.com/rs/zerolog/log
go: found github.com/rs/zerolog/log in github.com/rs/zerolog
v1.26.1
```

```
$ go mod vendor
```

After the `go mod vendor` command is executed, a `vendor` directory will be created.

```
├── go.mod
├── go.sum
├── go.work
├── main.go
└── vendor
    ├── github.com
    │   └── rs
    │       └── zerolog
    │           └── ...
    └── modules.txt
```

Packages

In this tutorial, we will talk about packages.

What are packages?

A package is nothing but a directory containing one or more Go source files, or other Go packages.

This means every Go source file must belong to a package and package declaration is done at top of every source file as follows.

```
package <package_name>
```

So far, we've done everything inside of `package main`. By convention, executable programs (by that I mean the ones with the `main` package) are called *Commands*, others are simply called *Packages*.

The `main` package should also contain a `main()` function which is a special function that acts as the entry point of an executable program.

Let's take a look at an example by creating our own package `custom` and adding some source files to it such as `code.go`.

```
package custom
```

Before we proceed any further, we should talk about imports and exports. Just like other languages, go also has a concept of imports and exports but it's very elegant.

Basically, any value (like a variable or function) can be exported and visible from other packages if they have been defined with an upper case identifier.

Let's try an example in our `custom` package.

```
package custom

var value int = 10 // Will not be exported
var Value int = 20 // Will be exported
```

As we can see lower case identifiers will not be exported and will be private to the package it's defined in. In our case the `custom` package.

That's great but how do we import or access it? Well, same as we've been doing so far unknowingly. Let's go to our `main.go` file and import our `custom` package.

Here we can refer to it using the `module` we had initialized in our `go.mod` file earlier.

```
---go.mod---
module example

go 1.18

---main.go--
package main

import "example/custom"

func main() {
	custom.Value
}
```

Notice how the package name is the last name of the import path.

We can import multiple packages as well like this.

```
package main

import (
	"fmt"

	"example/custom"
)

func main() {
	fmt.Println(custom.Value)
}
```

We can also alias our imports to avoid collisions like this.

```
package main

import (
	"fmt"

	abcd "example/custom"
)

func main() {
	fmt.Println(abcd.Value)
}
```

External Dependencies

In Go, we are not only limited to working with local packages, we can also install external packages using go install command as we saw earlier.

So let's download a simple logging package `github.com/rs/zerolog/log`.

```
$ go install github.com/rs/zerolog
```

```
package main

import (
	"github.com/rs/zerolog/log"

	abcd "example/custom"
)

func main() {
	log.Print(abcd.Value)
}
```

Also, make sure to check out the go doc of packages you install, which is usually located in the project's readme file. go doc parses the source code and generates documentation in HTML format. Reference to It is usually located in readme files.

Lastly, I will add that, Go doesn't have a particular *"folder structure"* convention, always try to organize your packages in a simple and intuitive way.

Workspaces

In this tutorial, we will learn about multi-module workspaces that were introduced in Go 1.18.

Workspaces allow us to work with multiple modules simultaneously without having to edit `go.mod` files for each module. Each module within a workspace is treated as a root module when resolving dependencies.

To understand this better, let's start by creating a `hello` module.

```
$ mkdir workspaces && cd workspaces
$ mkdir hello && cd hello
$ go mod init hello
```

For demonstration purposes, I will add a simple `main.go` and install an example package.

```
package main

import (
	"fmt"

	"golang.org/x/example/stringutil"
)

func main() {
	result := stringutil.Reverse("Hello Workspace")
	fmt.Println(result)
}
```

```
$ go get golang.org/x/example
go: downloading golang.org/x/example
v0.0.0-20220412213650-2e68773dfca0
go: added golang.org/x/example v0.0.0-20220412213650-2e68773dfca0
```

And if we run this, we should see our output in reverse.

```
$ go run main.go
ecapskroW olleH
```

This is great, but what if we want to modify the `stringutil` module that our code depends on?

Until now, we had to do it using the `replace` directive in the `go.mod` file, but now let's see how we can use workspaces here.

So, let's create our `workspace` in the workspaces directory.

```
$ go work init
```

This will create a `go.work` file.

```
$ cat go.work
go 1.18
```

We will also add our `hello` module to the workspace.

```
$ go work use ./hello
```

This should update the `go.work` file with a reference to our `hello` module.

```
go 1.18

use ./hello
```

Now, let's download and modify the `stringutil` package and update the `Reverse` function implementation.

```
$ git clone https://go.googlesource.com/example
Cloning into 'example'...
remote: Total 204 (delta 39), reused 204 (delta 39)
Receiving objects: 100% (204/204), 467.53 KiB | 363.00 KiB/s,
done.
Resolving deltas: 100% (39/39), done.
```

example/stringutil/reverse.go

```
func Reverse(s string) string {
      return fmt.Sprintf("I can do whatever!! %s", s)
}
```

Finally, let's add `example` package to our workspace.

```
$ go work use ./example
$ cat go.work
go 1.18

use (
      ./example
      ./hello
)
```

Perfect, now if we run our `hello` module we will notice that the `Reverse` function has been modified.

```
$ go run hello
I can do whatever!! Hello Workspace
```

This is a very underrated feature from Go 1.18 but it is quite useful in certain circumstances.

Useful Commands

During our module discussion, we discussed some go commands related to go modules, let's now discuss some other important commands.

Starting with `go fmt`, which formats the source code and it's enforced by that language so that we can focus on how our code should work rather than how our code should look.

```
$ go fmt
```

This might seem a little weird at first especially if you're coming from a javascript or python background like me but frankly, it's quite nice not to worry about linting rules.

Next, we have `go vet` which reports likely mistakes in our packages.

So, if I go ahead and make a mistake in the syntax, and then run `go vet`.

It should notify me of the errors.

```
$ go vet
```

Next, we have `go env` which simply prints all the go environment information, we'll learn about some of these build-time variables later.

Lastly, we have `go doc` which shows documentation for a package or symbol, here's an example of the `fmt` package.

```
$ go doc -src fmt Printf
```

Let's use `go help` command to see what other commands are available.

```
$ go help
```

As we can see, we have:

`go fix` finds Go programs that use old APIs and rewrites them to use newer ones.

`go generate` is usually used for code generation.

`go install` compiles and installs packages and dependencies.

`go clean` is used for cleaning files that are generated by compilers.

Some other very important commands are `go build` and `go test` but we will learn about them in detail later in the course.

Build

Building static binaries is one of the best features of Go which enables us to ship our code efficiently.

We can do this very easily using the `go build` command.

```
package main

import "fmt"

func main() {
      fmt.Println("I am a binary!")
}
```

```
$ go build
```

This should produce a binary with the name of our module. For example, here we have `example`.

We can also specify the output.

```
$ go build -o app
```

Now to run this, we simply need to execute it.

```
$ ./app
I am a binary!
```

Yes, it's as simple as that!

Now, let's talk about some important build time variables, starting with:

- `GOOS` and `GOARCH`

These environment variables help us build go programs for different operating systems and underlying processor architectures.

We can list all the supported architecture using `go tool` command.

```
$ go tool dist list
android/amd64
ios/amd64
js/wasm
linux/amd64
windows/arm64
.
.
.
```

Here's an example for building a windows executable from macOS!

```
$ GOOS=windows GOARCH=amd64 go build -o app.exe
```

- `CGO_ENABLED`

This variable allows us to configure CGO, which is a way in Go to call C code.

This helps us to produce a statically linked binary that works without any external dependencies.

This is quite helpful for, let's say when we want to run our go binaries in a docker container with minimum external dependencies.

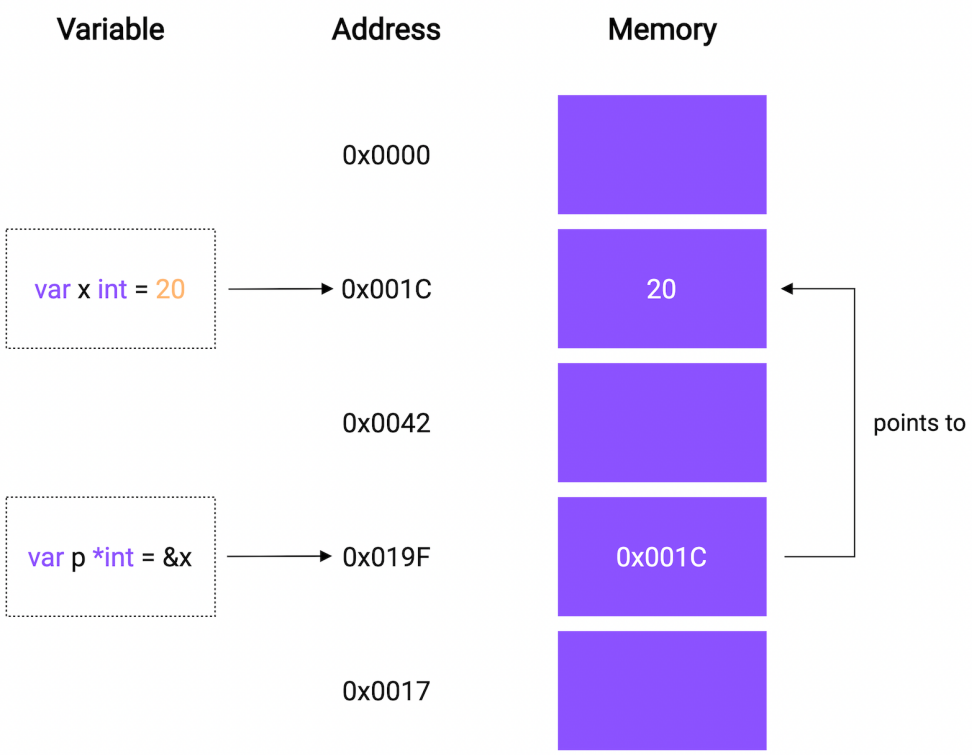
Here's an example of how to use it:

```
$ CGO_ENABLED=0 go build -o app
```

Pointers

In this tutorial, we will discuss pointers. So what are Pointers?

Simply defined, a Pointer is a variable that is used to store the memory address of another variable.



It can be used like this:

```
var x *T
```

Where `T` is the type such as `int`, `string`, `float`, and so on.

Let's try a simple example and see it in action.

```go
package main

import "fmt"

func main() {
	var p *int

	fmt.Println(p)
}
```

```
$ go run main.go
nil
```

Hmm, this prints `nil`, but what is `nil`?

So nil is a predeclared identifier in Go that represents zero value for pointers, interfaces, channels, maps, and slices.

This is just like what we learned in the variables and datatypes section, where we saw that uninitialized `int` has a zero value of 0, a `bool` has false, and so on.

Okay, now let's assign a value to the pointer.

```go
package main

import "fmt"

func main() {
	a := 10

	var p *int = &a

	fmt.Println("address:", p)
}
```

We use the & ampersand operator to refer to a variable's memory address.

```
$ go run main.go
0xc0000b8000
```

This must be the value of the memory address of the variable `a`.

Dereferencing

We can also use the * asterisk operator to retrieve the value stored in the variable that the pointer points to. This is also called **dereferencing**.

For example, we can access the value of the variable `a` through the pointer `p` using that * asterisk operator.

```
package main

import "fmt"

func main() {
	a := 10

	var p *int = &a

	fmt.Println("address:", p)
	fmt.Println("value:", *p)
}
```

```
$ go run main.go
address: 0xc000018030
value: 10
```

We can not only access it but change it as well through the pointer.

```
package main

import "fmt"

func main() {
	a := 10

	var p *int = &a

	fmt.Println("before", a)
```

```
	fmt.Println("address:", p)

	*p = 20
	fmt.Println("after:", a)
}
```

```
$ go run main.go
before 10
address: 0xc000192000
after: 20
```

I think this is pretty neat!

Pointers as function args

Pointers can also be used as arguments for a function when we need to pass some data by reference.

Here's an example:

```
myFunction(&a)
...

func myFunction(ptr *int) {}
```

New function

There's also another way to initialize a pointer. We can use the `new` function which takes a type as an argument, allocates enough memory to accommodate a value of that type, and returns a pointer to it.

Here's an example:

```
package main

import "fmt"

func main() {
	p := new(int)
	*p = 100
```

```
	fmt.Println("value", *p)
	fmt.Println("address", p)
}
```

```
$ go run main.go
value 100
address 0xc000018030
```

Pointer to a Pointer

Here's an interesting idea...can we create a pointer to a pointer? The answer is yes! Yes, we can.

```
package main

import "fmt"

func main() {
	p := new(int)
	*p = 100

	p1 := &p

	fmt.Println("P value", *p, " address", p)
	fmt.Println("P1 value", *p1, " address", p)

	fmt.Println("Dereferenced value", **p1)
}
```

```
$ go run main.go
P value 100  address 0xc0000be000
P1 value 0xc0000be000  address 0xc0000be000
Dereferenced value 100
```

Notice how the value of `p1` matches the address of `p`.

Also, it is important to know that pointers in Go do not support pointer arithmetic like in C or C++.

```
    p1 := p * 2 // Compiler Error: invalid operation
```

However, we can compare two pointers of the same type for equality using a == operator.

```
p := &a
p1 := &a

fmt.Println(p == p1)
```

But Why?

This brings us to the million-dollar question, why do we need pointers?

Well, there's no definite answer for that, and pointers are just another useful feature that helps us mutate our data efficiently without copying a large amount of data.

Lastly, I will add that if you are coming from a language with no notion of pointers, don't panic and try to form a mental model of how pointers work.

Structs

In this tutorial, we will learn about structs.

So, a `struct` is a user-defined type that contains a collection of named fields. Basically, it is used to group related data together to form a single unit.

If you're coming from an objected-oriented background, think of structs as lightweight classes which that support composition but not inheritance.

Defining

We can define a `struct` like this:

```
type Person struct {}
```

We use the `type` keyword to introduce a new type, followed by the name and then the `struct` keyword to indicate that we're defining a struct.

Now, let's give it some fields:

```
type Person struct {
      FirstName string
      LastName  string
      Age       int
}
```

And, if the fields have the same type, we can collapse them as well.

```
type Person struct {
      FirstName, LastName string
      Age                 int
}
```

Declaring and initializing

Now that we have our struct, we can declare it the same as other datatypes.

```
func main() {
	var p1 Person

	fmt.Println("Person 1:", p1)
}
```

```
$ go run main.go
Person 1: {  0}
```

As we can see, all the struct fields are initialized with their zero values. So the `FirstName` and `LastName` are set to `""` empty string and `Age` is set to 0.

We can also initialize it as *"struct literal"*.

```
func main() {
	var p1 Person

	fmt.Println("Person 1:", p1)

	var p2 = Person{FirstName: "Karan", LastName: "Pratap Singh",
Age: 22}

	fmt.Println("Person 2:", p2)
}
```

For readability, we can separate by new line but this will also require a trailing comma.

```
	var p2 = Person{
		FirstName: "Karan",
		LastName:  "Pratap Singh",
		Age:       22,
	}
```

```
$ go run main.go
Person 1: {  0}
Person 2: {Karan Pratap Singh 22}
```

We can also initialize only a subset of fields.

```
func main() {
      var p1 Person

      fmt.Println("Person 1:", p1)

      var p2 = Person{
            FirstName: "Karan",
            LastName:  "Pratap Singh",
            Age:       22,
      }

      fmt.Println("Person 2:", p2)

      var p3 = Person{
            FirstName: "Tony",
            LastName:  "Stark",
      }

      fmt.Println("Person 3:", p3)
}
```

```
$ go run main.go
Person 1: {  0}
Person 2: {Karan Pratap Singh 22}
Person 3: {Tony Stark 0}
```

As we can see, the age field of person 3 has defaulted to the zero value.

Without field name

Go structs also supports initialization without field names.

```
func main() {
	var p1 Person

	fmt.Println("Person 1:", p1)

	var p2 = Person{
		FirstName: "Karan",
		LastName:  "Pratap Singh",
		Age:       22,
	}

	fmt.Println("Person 2:", p2)

	var p3 = Person{
		FirstName: "Tony",
		LastName:  "Stark",
	}

	fmt.Println("Person 3:", p3)

	var p4 = Person{"Bruce", "Wayne"}

	fmt.Println("Person 4:", p4)
}
```

But here's the catch, we will need to provide all the values during the initialization or it will fail.

```
$ go run main.go
# command-line-arguments
./main.go:30:27: too few values in Person{...}
```

```
	var p4 = Person{"Bruce", "Wayne", 40}

	fmt.Println("Person 4:", p4)
```

We can also declare an anonymous struct.

```
func main() {
	var p1 Person

	fmt.Println("Person 1:", p1)

	var p2 = Person{
		FirstName: "Karan",
		LastName:  "Pratap Singh",
		Age:       22,
	}

	fmt.Println("Person 2:", p2)

	var p3 = Person{
		FirstName: "Tony",
		LastName:  "Stark",
	}

	fmt.Println("Person 3:", p3)

	var p4 = Person{"Bruce", "Wayne", 40}

	fmt.Println("Person 4:", p4)

	var a = struct {
		Name string
	}{"Golang"}

	fmt.Println("Anonymous:", a)
}
```

Accessing fields

Let's clean up our example a bit and see how we can access individual fields.

```
func main() {
	var p = Person{
		FirstName: "Karan",
		LastName:  "Pratap Singh",
		Age:       22,
	}
```

```
	fmt.Println("FirstName", p.FirstName)
}
```

We can also create a pointer to structs as well.

```
func main() {
	var p = Person{
		FirstName: "Karan",
		LastName:  "Pratap Singh",
		Age:       22,
	}

	ptr := &p

	fmt.Println((*ptr).FirstName)
	fmt.Println(ptr.FirstName)
}
```

Both statements are equal as in Go we don't need to explicitly dereference the pointer. We can also use the built-in `new` function.

```
func main() {
	p := new(Person)

	p.FirstName = "Karan"
	p.LastName = "Pratap Singh"
	p.Age = 22

	fmt.Println("Person", p)
}
```

```
$ go run main.go
Person &{Karan Pratap Singh 22}
```

As a side note, two structs are equal if all their corresponding fields are equal as well.

```
func main() {
      var p1 = Person{"a", "b", 20}
      var p2 = Person{"a", "b", 20}

      fmt.Println(p1 == p2)
}
```

```
$ go run main.go
true
```

Exported fields

Now let's learn what is exported and unexported fields in a struct. Same as the rules for variables and functions, if a struct field is declared with a lower case identifier, it will not be exported and only be visible to the package it is defined in.

```
type Person struct {
      FirstName, LastName  string
      Age                  int
      zipCode              string
}
```

So, the `zipCode` field won't be exported. Also, the same goes for the `Person` struct, if we rename it as `person`, it won't be exported as well.

```
type person struct {
      FirstName, LastName  string
      Age                  int
      zipCode              string
}
```

Embedding and composition

As we discussed earlier, Go doesn't necessarily support inheritance, but we can do something similar with embedding.

```
type Person struct {
      FirstName, LastName  string
      Age                  int
}
```

```
type SuperHero struct {
      Person
      Alias string
}
```

So, our new struct will have all the properties of the original struct. And it should behave the same as our normal struct.

```
func main() {
      s := SuperHero{}

      s.FirstName = "Bruce"
      s.LastName = "Wayne"
      s.Age = 40
      s.Alias = "batman"

      fmt.Println(s)
}
```

```
$ go run main.go
{{Bruce Wayne 40} batman}
```

However, this is usually not recommended and in most cases, composition is preferred. So rather than embedding, we will just define it as a normal field.

```
type Person struct {
      FirstName, LastName  string
      Age                  int
}

type SuperHero struct {
      Person Person
      Alias  string
}
```

Hence, we can rewrite our example with composition as well.

```
func main() {
      p := Person{"Bruce", "Wayne", 40}
      s := SuperHero{p, "batman"}

      fmt.Println(s)
}
```

```
$ go run main.go
{{Bruce Wayne 40} batman}
```

Again, there is no right or wrong here, but nonetheless, embedding comes in handy sometimes.

Struct tags

A struct tag is just a tag that allows us to attach metadata information to the field which can be used for custom behavior using the `reflect` package.

Let's learn how we can define struct tags.

```
type Animal struct {
      Name    string `key:"value1"`
      Age     int    `key:"value2"`
}
```

You will often find tags in encoding packages, such as XML, JSON, YAML, ORMs, and Configuration management.

Here's a tags example for the JSON encoder.

```
type Animal struct {
      Name    string `json:"name"`
      Age     int    `json:"age"`
}
```

Properties

Finally, let's discuss the properties of structs.

Structs are value types. When we assign one `struct` variable to another, a new copy of the `struct` is created and assigned.

Similarly, when we pass a `struct` to another function, the function gets its own copy of the `struct`.

```
package main

import "fmt"

type Point struct {
      X, Y float64
}

func main() {
      p1 := Point{1, 2}
      p2 := p1 // Copy of p1 is assigned to p2

      p2.X = 2

      fmt.Println(p1) // Output: {1 2}
      fmt.Println(p2) // Output: {2 2}
}
```

Empty struct occupies zero bytes of storage.

```
package main

import (
      "fmt"
      "unsafe"
)

func main() {
      var s struct{}
      fmt.Println(unsafe.Sizeof(s)) // Output: 0
}
```

Methods

Let's talk about methods, sometimes also known as function receivers.

Technically, Go is not an object-oriented programming language. It doesn't have classes, objects, and inheritance.

However, Go has types. And, you can define **methods** on types.

A method is nothing but a function with a special *receiver* argument. Let's see how we can declare methods.

```
func (variable T) Name(params) (returnTypes) {}
```

The *receiver* argument has a name and a type. It appears between the `func` keyword and the method name.

For example, let's define a `Car` struct.

```
type Car struct {
      Name string
      Year int
}
```

Now, let us define a method like `IsLatest` which will tell us if a car was manufactured within the last 5 years.

```
func (c Car) IsLatest() bool {
      return c.Year >= 2017
}
```

As you can see, we can access the instance of `Car` using the receiver variable `c`. I like to think of it as `this` keyword from the object-oriented world.

Now we should be able to call this method after we initialize our struct, just like we do with classes in other languages.

```
func main() {
	c := Car{"Tesla", 2021}

	fmt.Println("IsLatest", c.IsLatest())
}
```

Methods with Pointer receivers

All the examples that we saw previously had a value receiver.

With a value receiver, the method operates on a copy of the value passed to it. Therefore, any modifications done to the receiver inside the methods are not visible to the caller.

For example, let's make another method called `UpdateName` which will update the name of the `Car`.

```
func (c Car) UpdateName(name string) {
	c.Name = name
}
```

Now, let's run this.

```
func main() {
	c := Car{"Tesla", 2021}

	c.UpdateName("Toyota")
	fmt.Println("Car:", c)
}
```

```
$ go run main.go
Car: {Tesla 2021}
```

Seems like the name wasn't updated, so now let's switch our receiver to pointer type and try again.

```
func (c *Car) UpdateName(name string) {
	c.Name = name
}
```

```
$ go run main.go
Car: {Toyota 2021}
```

As expected, methods with pointer receivers can modify the value to which the receiver points. Such modifications are visible to the caller of the method as well.

Properties

Let's also see some properties of the methods!

- Go is smart enough to interpret our function call correctly, and hence, pointer receiver method calls are just syntactic sugar provided by Go for convenience.

```
(&c).UpdateName(...)
```

- We can omit the variable part of the receiver as well if we're not using it.

```
func (Car) UpdateName(...) {}
```

- Methods are not limited to structs but can also be used with non-struct types as well.

```
package main

import "fmt"

type MyInt int

func (i MyInt) isGreater(value int) bool {
      return i > MyInt(value)
}

func main() {
      i := MyInt(10)

      fmt.Println(i.isGreater(5))
}
```

Why methods instead of functions?

So the question is, why use methods instead of functions?

As always, there's no particular answer for this, and in no way one is better than the other. Instead, they should be used appropriately when the situation arrives.

One thing I can think of right now is that methods can help us avoid naming conflicts.

Since a method is tied to a particular type, we can have the same method names for multiple receivers.

But in the end, it might just come down to preference, such as *"method calls are much easier to read and understand than function calls"* or the other way around.

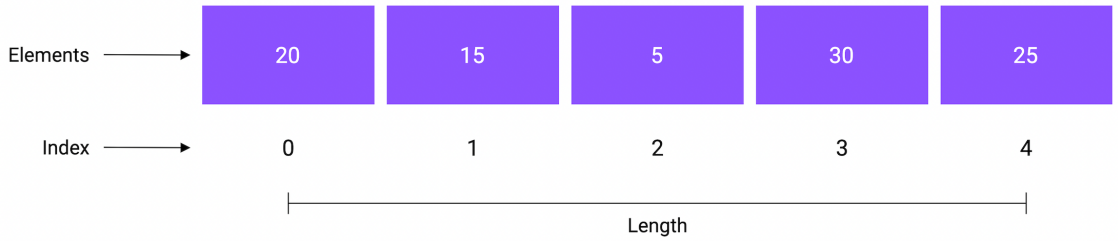
Arrays and Slices

In this tutorial, we will learn about arrays and slices in Go.

Arrays

What is an array?

An array is a fixed-size collection of elements of the same type. The elements of the array are stored sequentially and can be accessed using their `index`.



Declaration

We can declare an array as follows:

```
var a [n]T
```

Here, `n` is the length and `T` can be any type like integer, string, or user-defined structs.

Now, let's declare an array of integers with length 4 and print it.

```
func main() {
      var arr [4]int

      fmt.Println(arr)
}
```

```
$ go run main.go
[0 0 0 0]
```

By default, all the array elements are initialized with the zero value of the corresponding array type.

Initialization

We can also initialize an array using an array literal.

```
var a [n]T = [n]T{V1, V2, ... Vn}
```

```
func main() {
      var arr = [4]int{1, 2, 3, 4}

      fmt.Println(arr)
}
```

```
$ go run main.go
[1 2 3 4]
```

We can even do a shorthand declaration.

```
...
arr := [4]int{1, 2, 3, 4}
```

Access

And similar to other languages, we can access the elements using the `index` as they're stored sequentially.

```
func main() {
      arr := [4]int{1, 2, 3, 4}

      fmt.Println(arr[0])
}
```

```
$ go run main.go
1
```

Iteration

Now, let's talk about iteration.

So, there are multiple ways to iterate over arrays.

The first one is using the for loop with the `len` function which gives us the length of the array.

```
func main() {
	arr := [4]int{1, 2, 3, 4}

	for i := 0; i < len(arr); i++ {
		fmt.Printf("Index: %d, Element: %d\n", i, arr[i])
	}
}
```

```
$ go run main.go
Index: 0, Element: 1
Index: 1, Element: 2
Index: 2, Element: 3
Index: 3, Element: 4
```

Another way is to use the `range` keyword with the `for` loop.

```
func main() {
	arr := [4]int{1, 2, 3, 4}

	for i, e := range arr {
		fmt.Printf("Index: %d, Element: %d\n", i, e)
	}
}
```

```
$ go run main.go
Index: 0, Element: 1
Index: 1, Element: 2
Index: 2, Element: 3
Index: 3, Element: 4
```

As we can see, our example works the same as before.

But the range keyword is quite versatile and can be used in multiple ways.

```
for i, e := range arr {} // Normal usage of range

for _, e := range arr {} // Omit index with _ and use element

for i := range arr {} // Use index only

for range arr {} // Simply loop over the array
```

Multi dimensional

All the arrays that we created so far are one-dimensional. We can also create multi-dimensional arrays in Go.

Let's take a look at an example:

```
func main() {
	arr := [2][4]int{
		{1, 2, 3, 4},
		{5, 6, 7, 8},
	}

	for i, e := range arr {
		fmt.Printf("Index: %d, Element: %d\n", i, e)
	}
}
```

```
$ go run main.go
Index: 0, Element: [1 2 3 4]
Index: 1, Element: [5 6 7 8]
```

We can also let the compiler infer the length of the array by using `...` ellipses instead of the length.

```
func main() {
	arr := [...][4]int{
		{1, 2, 3, 4},
		{5, 6, 7, 8},
	}

	for i, e := range arr {
		fmt.Printf("Index: %d, Element: %d\n", i, e)
	}
}
```

```
$ go run main.go
Index: 0, Element: [1 2 3 4]
Index: 1, Element: [5 6 7 8]
```

Properties

Now let's talk about some properties of arrays.

The array's length is part of its type. So, the array `a` and `b` are completely distinct types, and we cannot assign one to the other.

This also means that we cannot resize an array, because resizing an array would mean changing its type.

```
package main

func main() {
	var a = [4]int{1, 2, 3, 4}
	var b [2]int = a // Error, cannot use a (type [4]int) as type
[2]int in assignment
}
```

Arrays in Go are value types unlike other languages like C, C++, and Java where arrays are reference types.

This means that when we assign an array to a new variable or pass an array to a function, the entire array is copied.

So, if we make any changes to this copied array, the original array won't be affected and will remain unchanged.

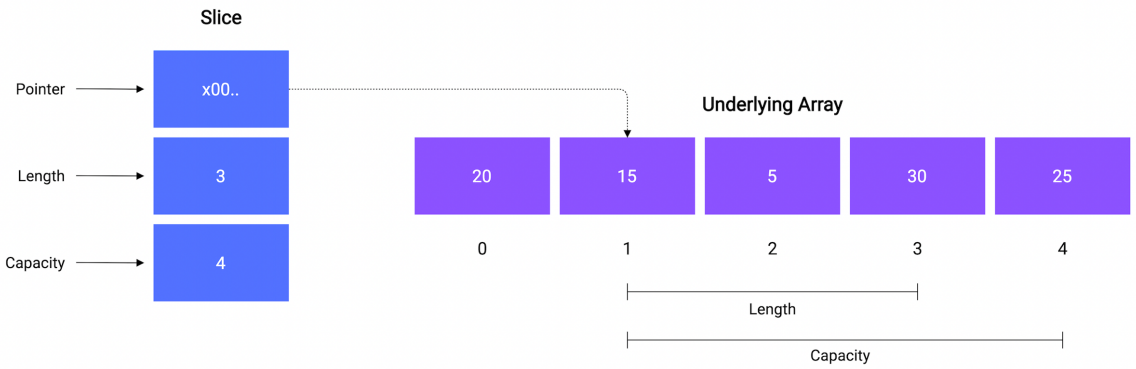
```
package main

import "fmt"

func main() {
	var a = [7]string{"Mon", "Tue", "Wed", "Thu", "Fri", "Sat",
"Sun"}
	var b = a // Copy of a is assigned to b

	b[0] = "Monday"

	fmt.Println(a) // Output: [Mon Tue Wed Thu Fri Sat Sun]
	fmt.Println(b) // Output: [Monday Tue Wed Thu Fri Sat Sun]
}
```

Slices

I know what you're thinking, arrays are useful but a bit inflexible due to the limitation caused by their fixed size.

This brings us to Slice, so what is a slice?

A Slice is a segment of an array. Slices build on arrays and provide more power, flexibility, and convenience.



A slice consists of three things:

- A pointer reference to an underlying array.
- The length of the segment of the array that the slice contains.
- And, the capacity, which is the maximum size up to which the segment can grow.

Just like `len` function, we can determine the capacity of a slice using the built-in `cap` function. Here's an example:

```
package main

import "fmt"

func main() {
	a := [5]int{20, 15, 5, 30, 25}

	s := a[1:4]

	// Output: Array: [20 15 5 30 25], Length: 5, Capacity: 5
	fmt.Printf("Array: %v, Length: %d, Capacity: %d\n", a,
len(a), cap(a))

	// Output: Slice [15 5 30], Length: 3, Capacity: 4
	fmt.Printf("Slice: %v, Length: %d, Capacity: %d", s, len(s),
cap(s))
}
```

Don't worry, we are going to discuss everything shown here in detail.

Declaration

Let's see how we can declare a slice.

```
var s []T
```

As we can see, we don't need to specify any length. Let's declare a slice of integers and see how it works.

```
func main() {
	var s []string

	fmt.Println(s)
	fmt.Println(s == nil)
}
```

```
$ go run main.go
[]
true
```

So, unlike arrays, the zero value of a slice is `nil`.

Initialization

There are multiple ways to initialize our slice. One way is to use the built-in `make` function.

```
make([]T, len, cap) []T
```

```
func main() {
	var s = make([]string, 0, 0)

	fmt.Println(s)
}
```

```
$ go run main.go
[]
```

Similar to arrays, we can use the slice literal to initialize our slice.

```
func main() {
	var s = []string{"Go", "TypeScript"}

	fmt.Println(s)
}
```

```
$ go run main.go
[Go TypeScript]
```

Another way is to create a slice from an array. Since a slice is a segment of an array, we can create a slice from index `low` to `high` as follows.

```
a[low:high]
```

```
func main() {
	var a = [4]string{
		"C++",
		"Go",
		"Java",
		"TypeScript",
	}

	s1 := a[0:2] // Select from 0 to 2
	s2 := a[:3]  // Select first 3
	s3 := a[2:]  // Select last 2

	fmt.Println("Array:", a)
	fmt.Println("Slice 1:", s1)
	fmt.Println("Slice 2:", s2)
	fmt.Println("Slice 3:", s3)
}
```

```
$ go run main.go
Array: [C++ Go Java TypeScript]
Slice 1: [C++ Go]
Slice 2: [C++ Go Java]
Slice 3: [Java TypeScript]
```

Missing low index implies 0 and missing high index implies the length of the underlying array (`len(a)`).

The thing to note here is we can create a slice from other slices too and not just arrays.

```
var a = []string{
	"C++",
	"Go",
	"Java",
	"TypeScript",
}
```

Iteration

We can iterate over a slice in the same way you iterate over an array, by using the for loop with either `len` function or `range` keyword.

Functions

So now, let's talk about built-in slice functions provided in Go.

copy

The `copy()` function copies elements from one slice to another. It takes 2 slices, a destination, and a source. It also returns the number of elements copied.

```
func copy(dst, src []T) int
```

Let's see how we can use it.

```
func main() {
      s1 := []string{"a", "b", "c", "d"}
      s2 := make([]string, len(s1))

      e := copy(s2, s1)

      fmt.Println("Src:", s1)
      fmt.Println("Dst:", s2)
      fmt.Println("Elements:", e)
}
```

```
$ go run main.go
Src: [a b c d]
Dst: [a b c d]
Elements: 4
```

As expected, our 4 elements from the source slice were copied to the destination slice.

append

Now, let's look at how we can append data to our slice using the built-in `append` function which appends new elements at the end of a given slice.

It takes a slice and a variable number of arguments. It then returns a new slice containing all the elements.

```
append(slice []T, elems ...T) []T
```

Let's try it in an example by appending elements to our slice.

```
func main() {
	s1 := []string{"a", "b", "c", "d"}

	s2 := append(s1, "e", "f")

	fmt.Println("s1:", s1)
	fmt.Println("s2:", s2)
}
```

```
$ go run main.go
s1: [a b c d]
s2: [a b c d e f]
```

As we can see, the new elements were appended and a new slice was returned.

But if the given slice doesn't have sufficient capacity for the new elements then a new underlying array is allocated with a bigger capacity.

All the elements from the underlying array of the existing slice are copied to this new array, and then the new elements are appended.

Properties

Finally, let's discuss some properties of slices.

Slices are reference types, unlike arrays.

This means modifying the elements of a slice will modify the corresponding elements in the referenced array.

```
package main

import "fmt"

func main() {
	a := [7]string{"Mon", "Tue", "Wed", "Thu", "Fri", "Sat",
"Sun"}

	s := a[0:2]
```

```
	s[0] = "Sun"

	fmt.Println(a) // Output: [Sun Tue Wed Thu Fri Sat Sun]
	fmt.Println(s) // Output: [Sun Tue]
}
```

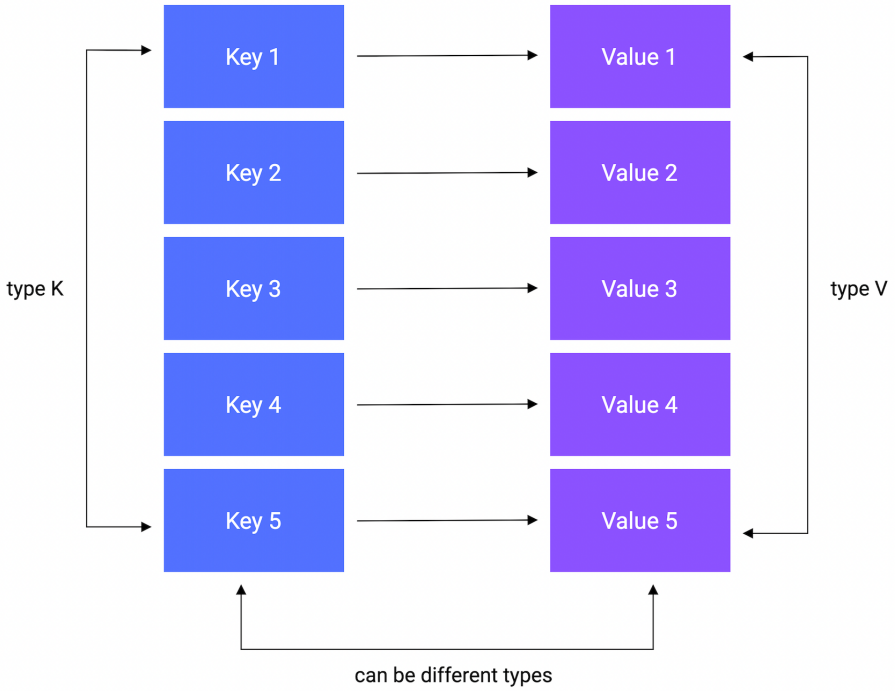
Slices can be used with variadic types as well.

```
package main

import "fmt"

func main() {
	values := []int{1, 2, 3}
	sum := add(values...)
	fmt.Println(sum)
}

func add(values ...int) int {
	sum := 0
	for _, v := range values {
		sum += v
	}

	return sum
}
```

Maps

So, Go provides a built-in map type, and we'll learn how to use it.

But, the question is what are maps? And why do we need them?



Well, A map is an unordered collection of key-value pairs. It maps keys to values. The keys are unique within a map while the values may not be.

It is used for fast lookups, retrieval, and deletion of data based on keys. It is one of the most used data structures.

Declaration

Let's start with the declaration.

A map is declared using the following syntax:

```
var m map[K]V
```

Where `K` is the key type and `V` is the value type.

For example, here's how we can declare a map of `string` keys to `int` values.

```
func main() {
      var m map[string]int

      fmt.Println(m)
}
```

```
$ go run main.go
nil
```

As we can see, the zero value of a map is `nil`.

A nil map has no keys. Moreover, any attempt to add keys to a nil map will result in a runtime error.

Initialization

There are multiple ways to initialize a map.

make function

We can use the built-in `make` function, which allocates memory for referenced data types and initializes their underlying data structures.

```
func main() {
      var m = make(map[string]int)

      fmt.Println(m)
}
```

```
$ go run main.go
map[]
```

map literal

Another way is using a map literal.

```
func main() {
      var m = map[string]int{
            "a": 0,
    "b": 1,
      }

      fmt.Println(m)
}
```

Note that the trailing comma is required.

```
$ go run main.go
map[a:0 b:1]
```

As always, we can use our custom types as well.

```
type User struct {
      Name string
}

func main() {
      var m = map[string]User{
            "a": User{"Peter"},
            "b": User{"Seth"},
      }

      fmt.Println(m)
}
```

We can even remove the value type and Go will figure it out!

```
var m = map[string]User{
      "a": {"Peter"},
      "b": {"Seth"},
}
```

```
$ go run main.go
map[a:{Peter} b:{Seth}]
```

Add

Now, let's see how we can add a value to our map.

```
func main() {
      var m = map[string]User{
            "a": {"Peter"},
            "b": {"Seth"},
      }

      m["c"] = User{"Steve"}

      fmt.Println(m)
}
```

```
$ go run main.go
map[a:{Peter} b:{Seth} c:{Steve}]
```

Retrieve

We can also retrieve our values from the map using the key.

```
...
c := m["c"]
fmt.Println("Key c:", c)
```

```
$ go run main.go
key c: {Steve}
```

What if we use a key that is not present in the map?

```
...
d := m["d"]
fmt.Println("Key d:", d)
```

Yes, you guessed it! we will get the zero value of the map's value type.

```
$ go run main.go
Key c: {Steve}
Key d: {}
```

Exists

When you retrieve the value assigned to a given key, it returns an additional boolean value as well. The boolean variable will be `true` if the key exists, and `false` otherwise.

Let's try this in an example:

```
...
c, ok := m["c"]
fmt.Println("Key c:", c, ok)

d, ok := m["d"]
fmt.Println("Key d:", d, ok)
```

```
$ go run main.go
Key c: {Steve} Present: true
Key d: {} Present: false
```

Update

We can also update the value for a key by simply re-assigning a key.

```
...
m["a"] = "Roger"
```

```
$ go run main.go
map[a:{Roger} b:{Seth} c:{Steve}]
```

Delete

Or, we can delete the key using the built-in `delete` function.

Here's how the syntax looks:

```
...
delete(m, "a")
```

The first argument is the map, and the second is the key we want to delete.

The `delete()` function doesn't return any value. Also, it doesn't do anything if the key doesn't exist in the map.

```
$ go run main.go
map[a:{Roger} c:{Steve}]
```

Iteration

Similar to arrays or slices, we can iterate over maps with the `range` keyword.

```
package main

import "fmt"

func main() {
	var m = map[string]User{
		"a": {"Peter"},
		"b": {"Seth"},
	}

	m["c"] = User{"Steve"}

	for key, value := range m {
		fmt.Println("Key: %s, Value: %v", key, value)
	}
}
```

```
$ go run main.go
Key: c, Value: {Steve}
Key: a, Value: {Peter}
Key: b, Value: {Seth}
```

Note that a map is an unordered collection, and therefore the iteration order of a map is not guaranteed to be the same every time we iterate over it.

Properties

Lastly, let's talk about map properties.

Maps are reference types, which means when we assign a map to a new variable, they both refer to the same underlying data structure.

Therefore, changes done by one variable will be visible to the other.

```
package main

import "fmt"

type User struct {
      Name string
}

func main() {
      var m1 = map[string]User{
            "a": {"Peter"},
            "b": {"Seth"},
      }

      m2 := m1
      m2["c"] = User{"Steve"}

      fmt.Println(m1) // Output: map[a:{Peter} b:{Seth} c:{Steve}]
      fmt.Println(m2) // Output: map[a:{Peter} b:{Seth} c:{Steve}]
}
```