Everything you need to know about Packages in Go

A complete overview of package management and deployment in Go programming language

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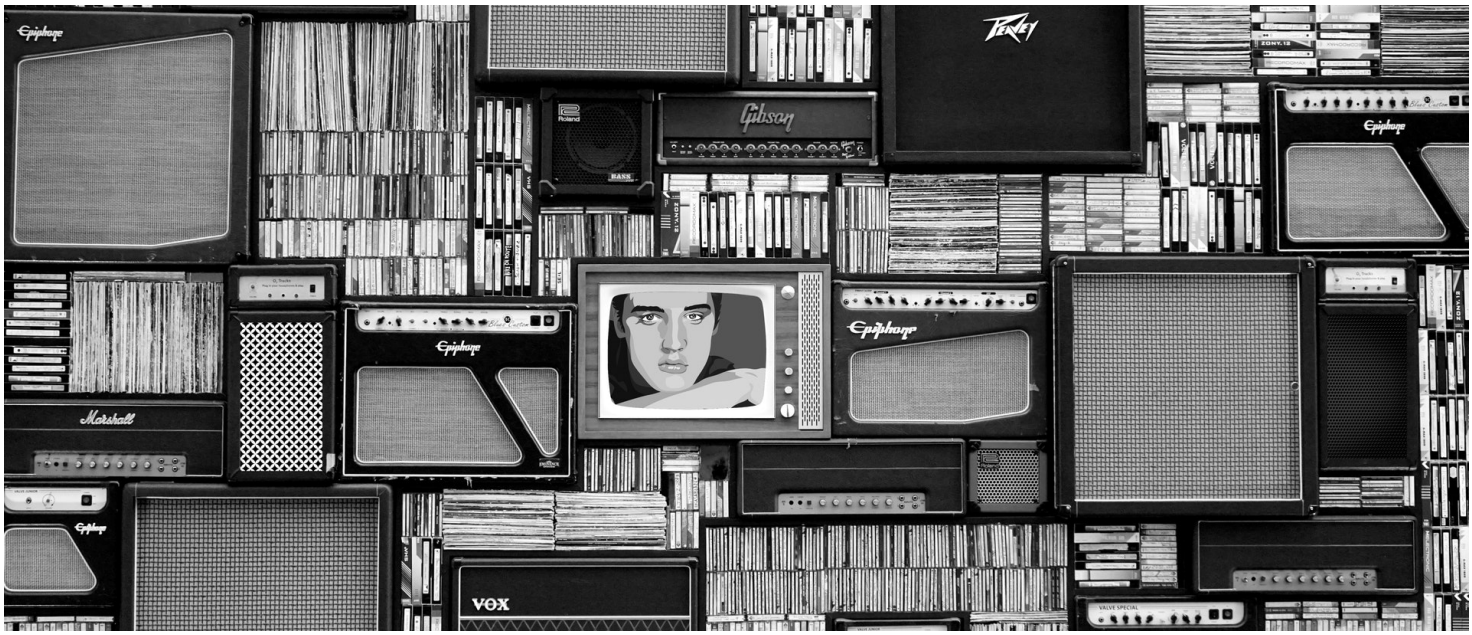


If you are familiar to languages like **Java** or **NodeJS**, then you might be quite familiar with **packages**. A package is nothing but a directory with some code files, which exposes different variables (*features*) from a single point of reference. Let me explain, what that means.

Imagine you have more than a thousand functions which you need constantly while working on any project. Some of these functions have common behavior. For example, `toUpperCase` and `toLowerCase` function transforms **case** of a `string`, so you write them in a single file (*probably* ***case.go***). There are other functions which do some other operations on `string` data type, so you write them in a separate file as well.

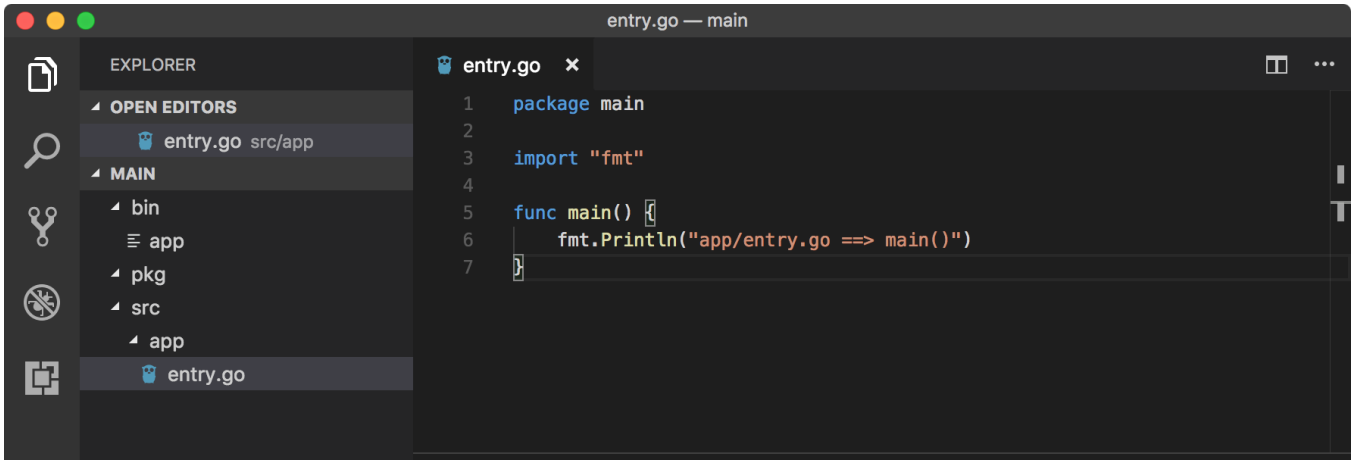
Since you have many files which do something with `string` data type, so you created a directory named `string` and put all `string` related files into it. Finally, you put all of these directories in one parent directory which will be your package. The whole package structure looks like below.

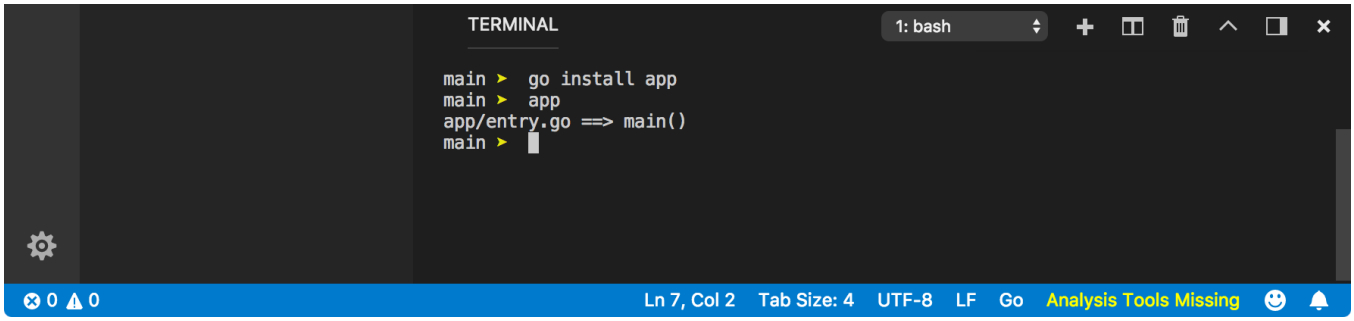
```
package-name
├── string
|   ├── case.go
|   ├── trim.go
|   └── misc.go
└── number
    ├── arithmetics.go
    └── primes.go
```

I will explain thoroughly, how we can import functions and variables from a package and how everything blends together to form a package, but for now, imagine your package as a directory containing `.go` files.

Every Go program **must be** a part of some package. As discussed in **Getting started with Go** lesson, a standalone executable Go program must have `package main` declaration. If a program is part of the main package, then `go install` will create a binary file; which upon execution calls `main` function of the program. If a program is part of package other than `main`, then a **package archive** file is created with `go install` command. **Don't worry, I will explain all this in upcoming topics.**

Let's create an executable package. As we know, to create a binary executable file, we need our program to be a part of `main` package and it must have `main` function which is the entry point of execution.



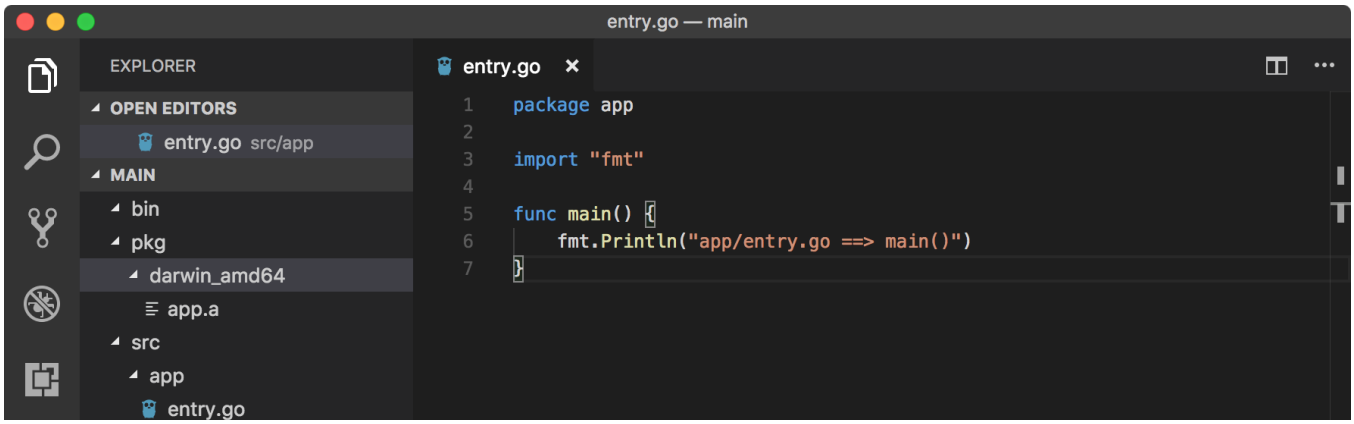


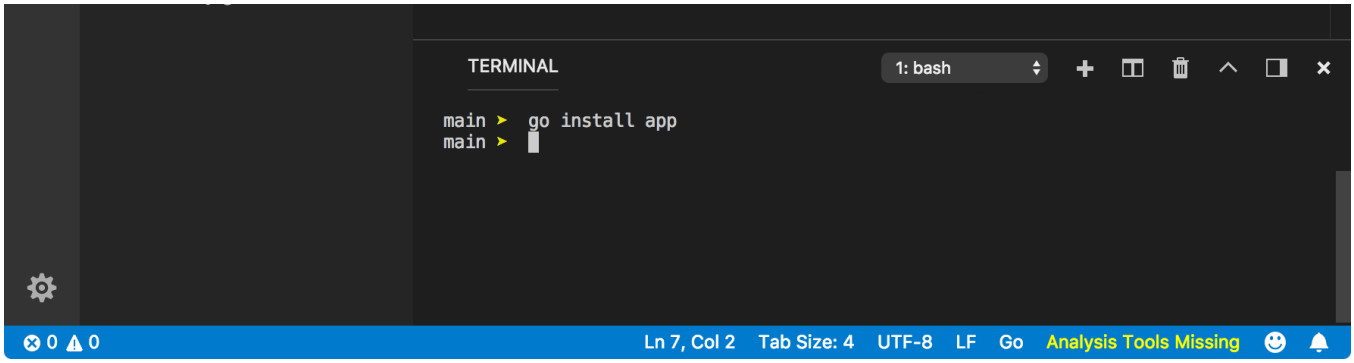
A package name is the name of the directory contained in `src` directory. In the above case, `app` is the package since `app` is the child directory of `src` directory. Hence, `go install app` command looked for `app` sub-directory inside `src` directory of `GOPATH`. Then it compiled the package and created `app` binary executable file inside `bin` directory which should be executable from the terminal since `bin` directory in the `PATH`.

> ***Package declaration*** *which should be first line of code like* `package main` *in above example, can be different than package name. Hence, you might find some packages where package name (**name of the directory**) is different than package declaration. When you import a package, package declaration is used to create package reference variable, explained later in the article.*

`go install <package>` command looks for any file with `main` **package declaration**inside given `package` directory. If it finds a file, then Go knows this is an executable program and it needs to create a binary file. A package can have many files but only one file with `main` function, since that file will be the entry point of the execution.

If a package does not contain a file with `main` package declaration, then Go creates a **package archive** (`.a`) file inside `pkg` directory.





Since, `app` is not an executable package, it created `app.a` file inside `pkg` directory. We can not execute this file as it's not a binary file.

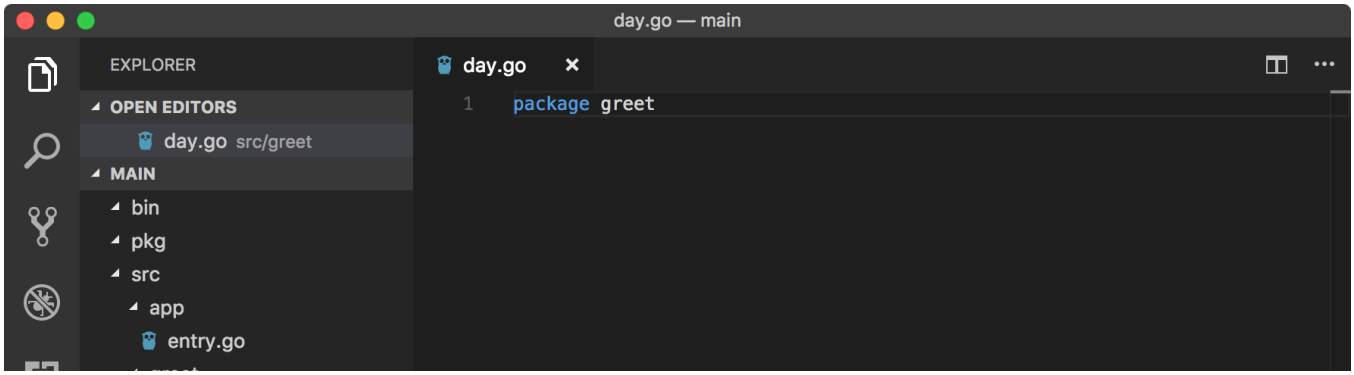
Package naming convention

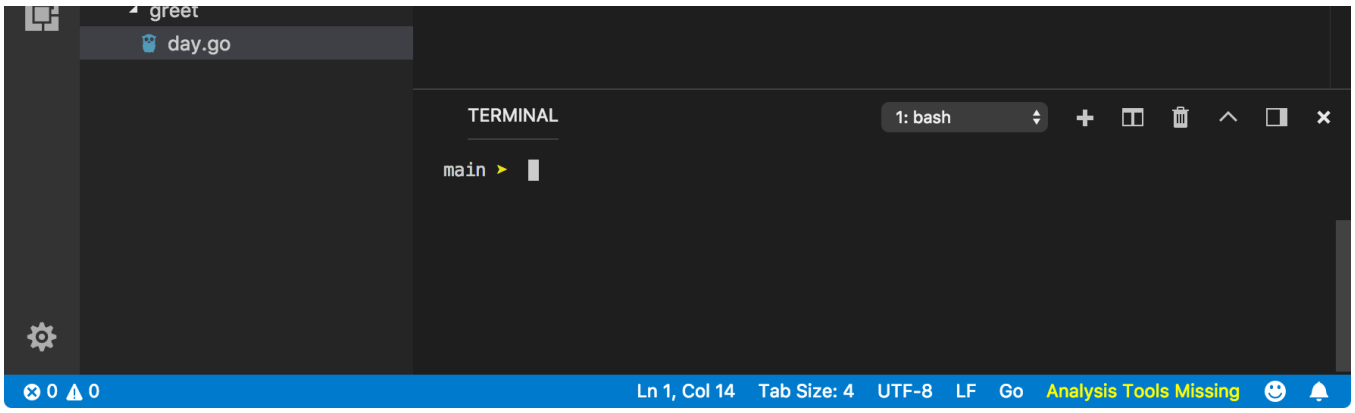
Go community recommends to use plain and simple names for packages. For example, `strutils` for **string utility** functions or `http` for HTTP requests related functions. A package names with `under_scores` , `hy-phens` or `mixedCaps` should be avoided.

Creating a package

As we discussed, there are two types of packages. An **executable package** and a **utility package**. An executable package is your main application since you will be running it. A utility package is not self-executable, instead, it enhances the functionality of an executable package by providing utility functions and other important assets.

As we know, a package nothing but a directory, let's create `greet` directory inside `src` and create few files in it. This time, we will write `package greet` a declaration on the top of each file to state that this is a utility package.



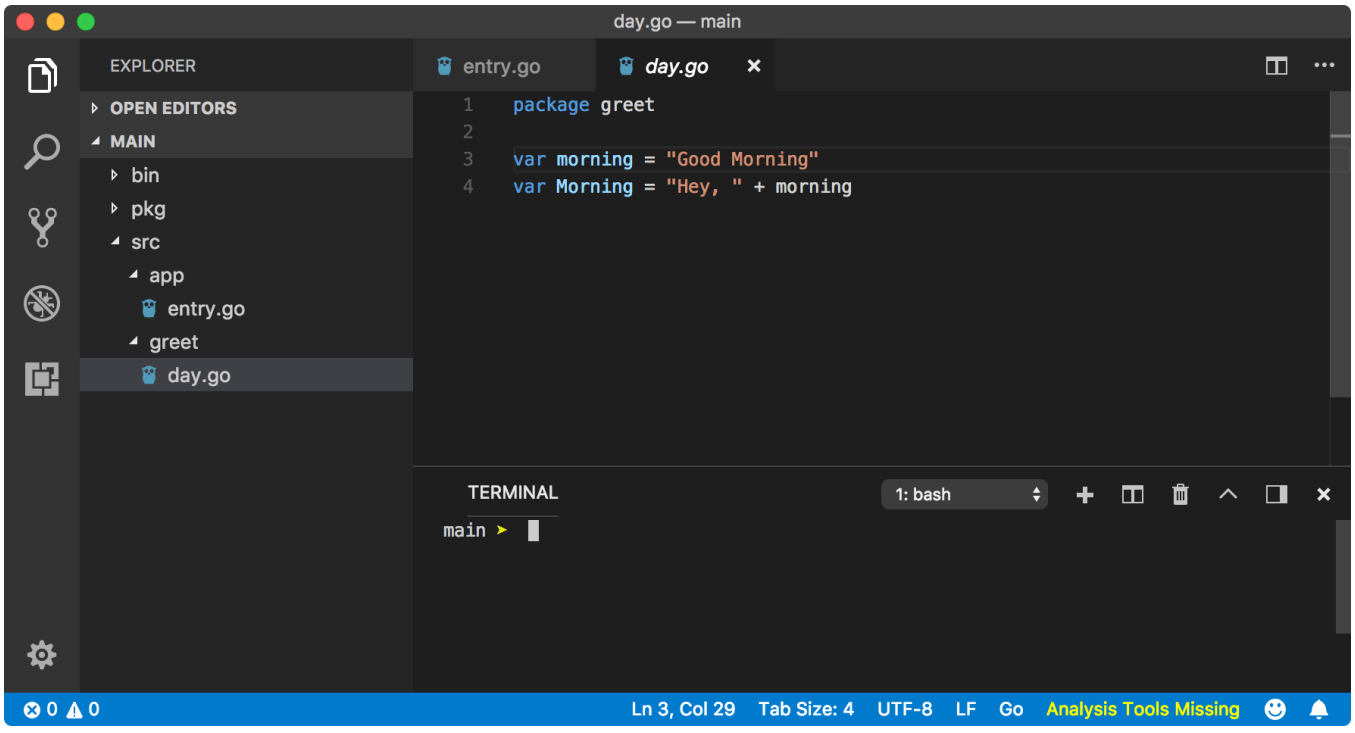


Export members

A utility package is supposed to provide some **variables** to a package who imports it. Like `export` syntax in `JavaScript`, Go exports a variable if a variable name starts with **Uppercase**. All other variables not starting with an uppercase letter is private to the package.

> *I am going to use **variable** word from now on in this article, to describe an export member but export members can be of any type like* `constant`, `map`, `function`, `struct`, *`array`*, *`slice`* *etc.*

Let's export a greeting variable from `day.go` file.



In the above program, `Morning` variable will be exported from the package but `morning` variable won't be since it starts with a lowercase letter.

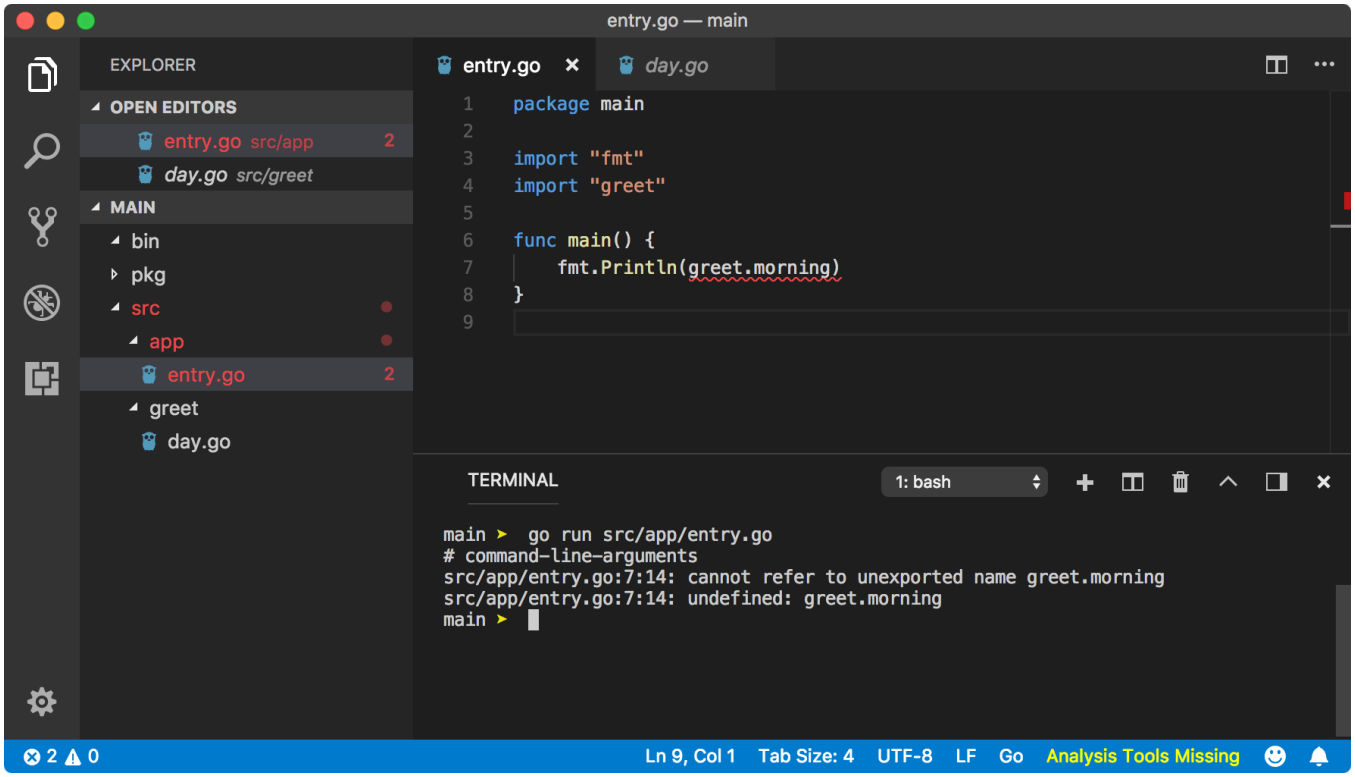
Importing a package

Now, we need an **executable package** which will consume our `greet` package. Let's create an `app` directory inside `src` and create `entry.go` file with `main` package declaration and `main` function. Note here, Go packages do not have an **entry file naming system** like `index.js` in Node. For an executable package, a file with `main` function is the entry file for execution.

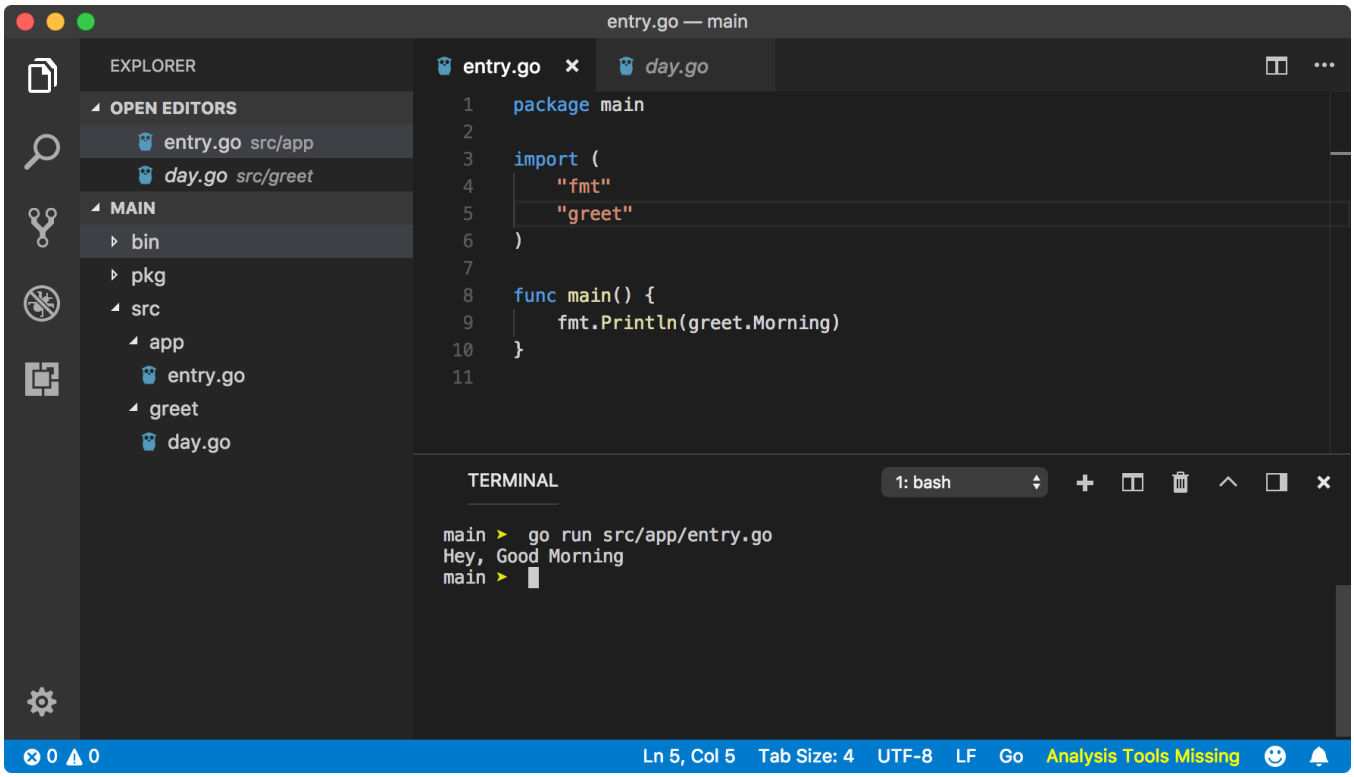
To import a package, we use `import` syntax followed by the **package name**.

> *Unlike other programming languages, a package name can also be a subpath like `some-dir/greet` and Go will automatically resolve the path to the `greet` package for us as seen in the **nested package** topic ahead.*

Go first searches for package directory inside `GOROOT/src` directory and if it doesn't find the package, then it looks for `GOPATH/src`. Since, `fmt` package is part of Go's standard library which is located in `GOROOT/src`, it is imported from there. Since Go cannot find `greet` package inside `GOROOT`, it will lookup inside `GOPATH/src` and we have it there.



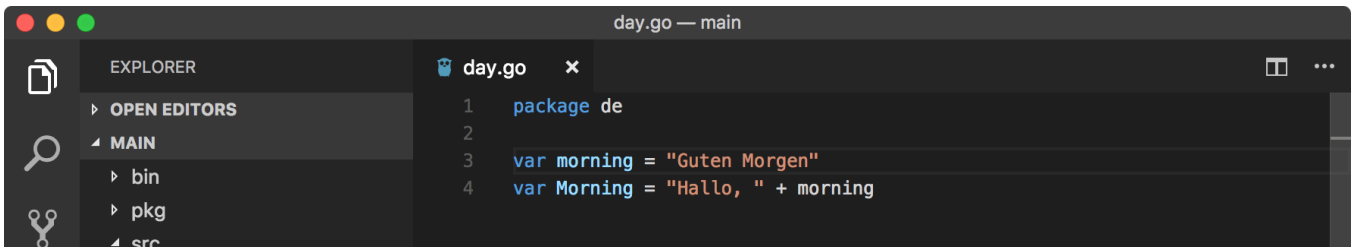
Above program throws compilation error, as `morning` variable is not visible from the package `greet`. As you can see, we use `.` (*dot*) notation to access exported members from a package. When you import a package, Go creates a global variable using the **package declaration** of the package. In the above case, `greet` is the global variable created by Go because we used `package greet` declaration in programs contained in `greet` package.

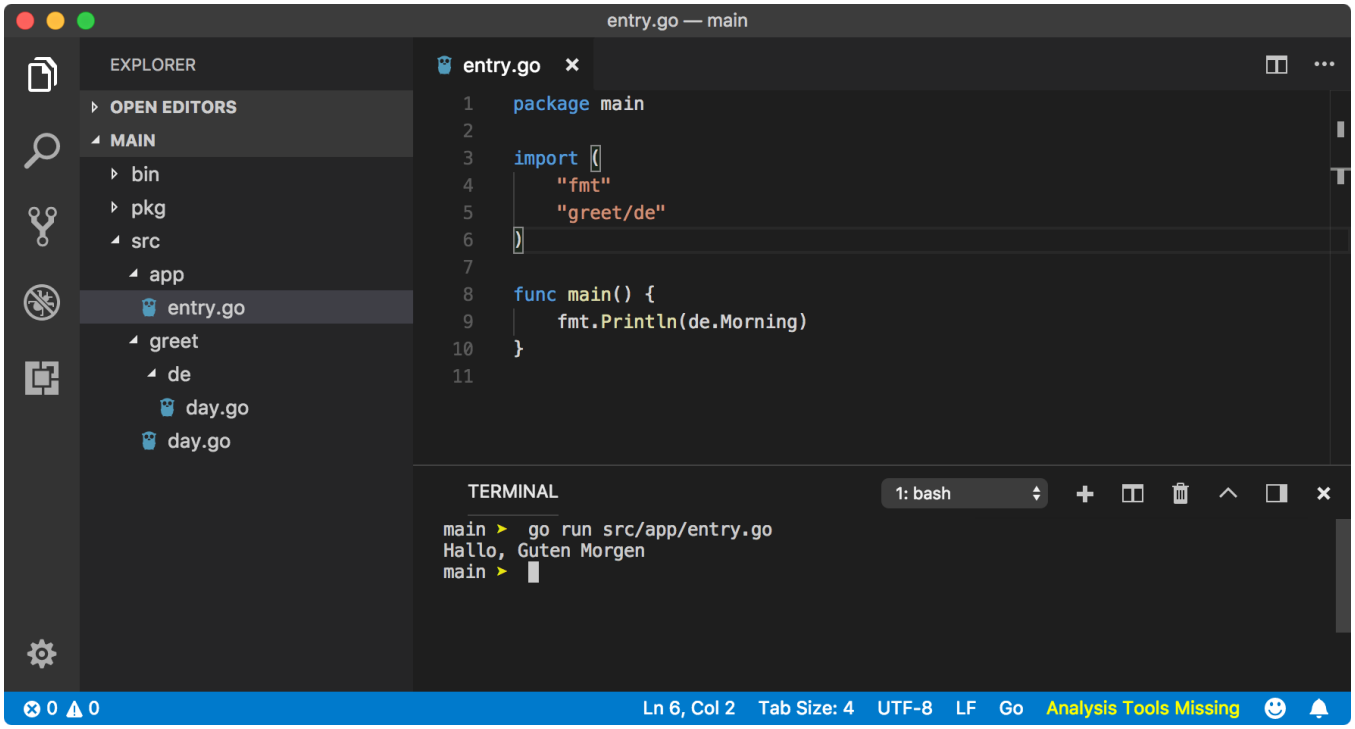


We can group `fmt` and `greet` package imports together using grouping syntax (*parentheses*). This time, our program will compile just fine, because `Morning` variable is available from outside the package.

Nested package

We can nest a package inside a package. Since for Go, a package is just a directory, it's like creating a subdirectory inside an already existing package. All we have to do is provide a relative path of the nested package.

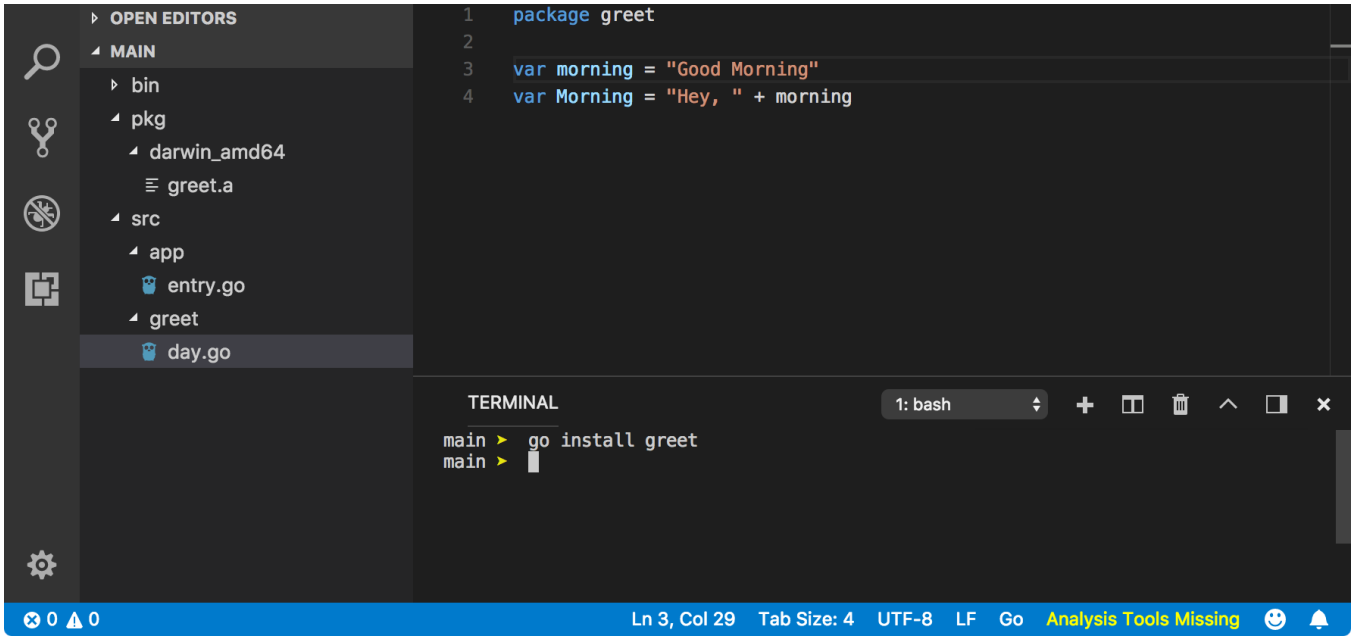




Package compilation

As discussed in the previous lesson, `go run` command compiles and executes a program. We know, `go install` command compiles packages and creates binary executable files or package archive files. This is to avoid compilation of package(s) every single time a (*program where these packages are imported*) is compiled . `go install` pre-compiles a package and Go refers to `.a` files.

> *Generally, when you install a 3rd party package, Go compiles the package and create package archive file. If you have written package locally, then your **IDE** might create package archive as soon as you save the file in the package or when package gets modified.* ***VSCode compiles the package when you save it if you have Go plugin installed.***

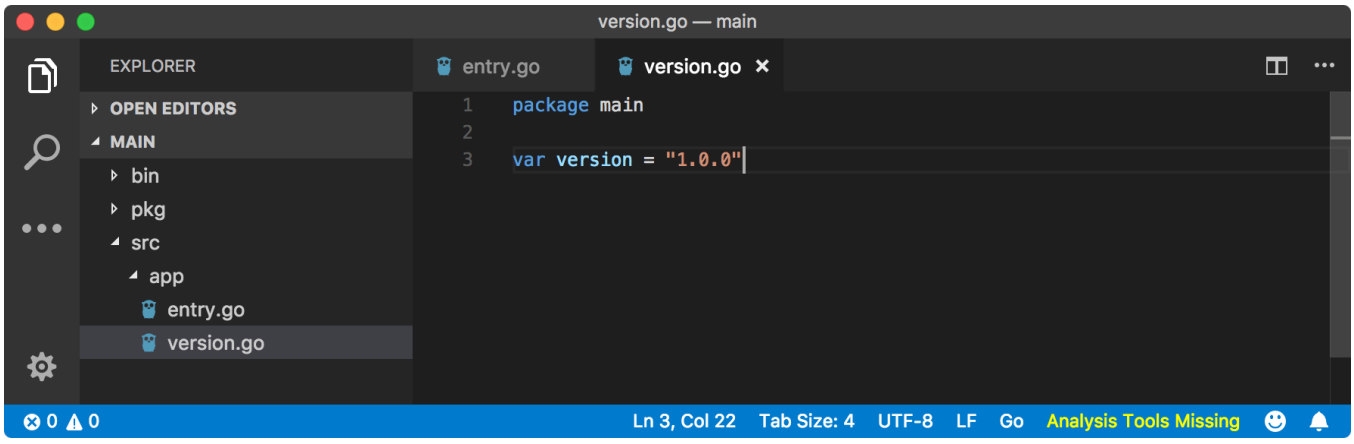


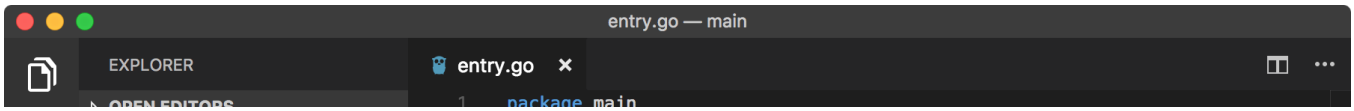
Package initialization

When we run a Go program, Go compiler follows a certain execution order for packages, files in a package and variable declaration in the package.

Package scope

A scope is a region in code block where a defined variable is accessible. A package scope is a region within a package where a declared variable is accessible from within a package (*across all files in the package*). This region is the top-most block of any file in the package.





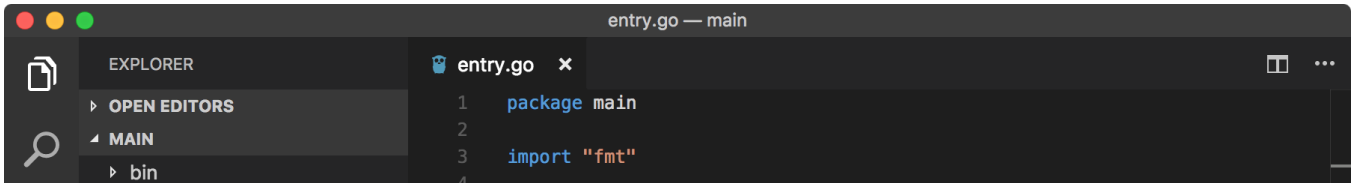
Take a look at `go run` command. This time, instead of executing one file, we have a glob pattern to include all files inside `app` package for execution. Go is smart enough to figure out an entry point of the application which is `entry.go` because it has `main` function. We can also use a command like below (*file name order doesn't matter*).

```
go run src/app/version.go src/app/entry.go
```

> `go install` *or* `go build` *command requires a package name, which includes all the files inside a package, so we don't have to specify them like above.*

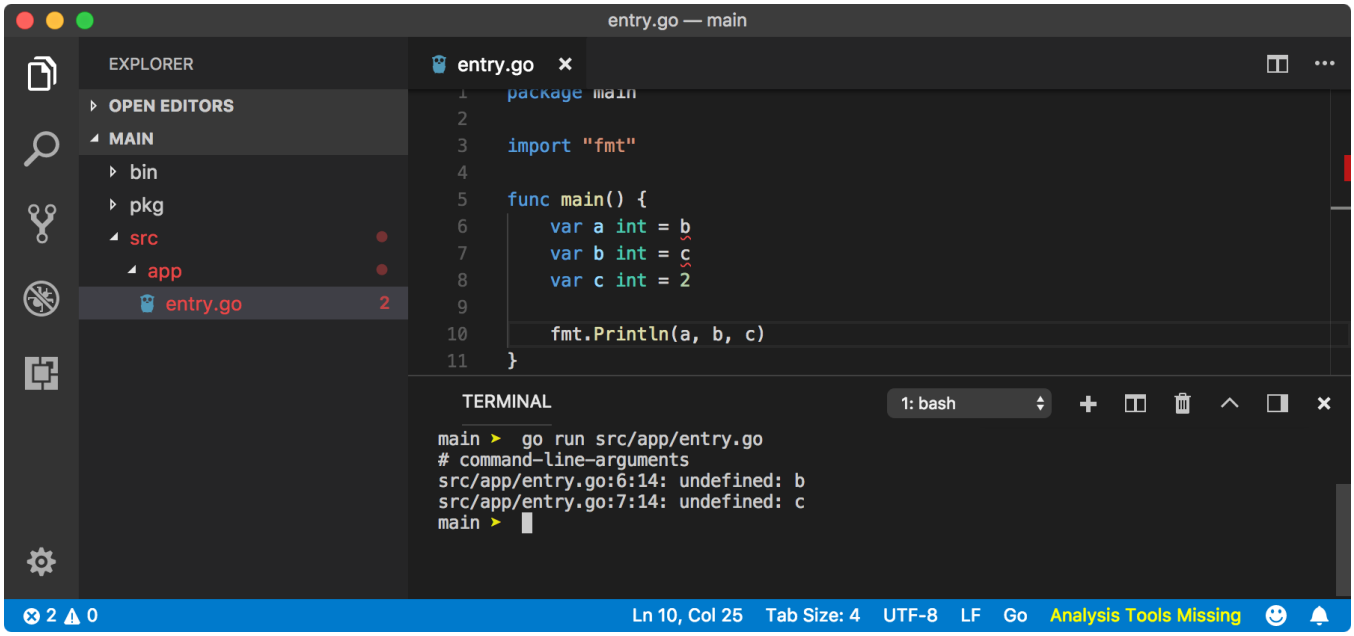
Coming back to our main issue, we can use variable `version` declared in `version.go` file from anywhere in the package even though it is not exported (*like* `Version`), because it is declared in package scope. If `version` variable would have been declared in a function, it wouldn't have been in package scope and above program would have failed to compile.

You are not allowed to re-declare global variable with the same name in the same package. Hence, once `version` variable is declared, it can not be re-declared in the package scope. But you are free to re-declare elsewhere.

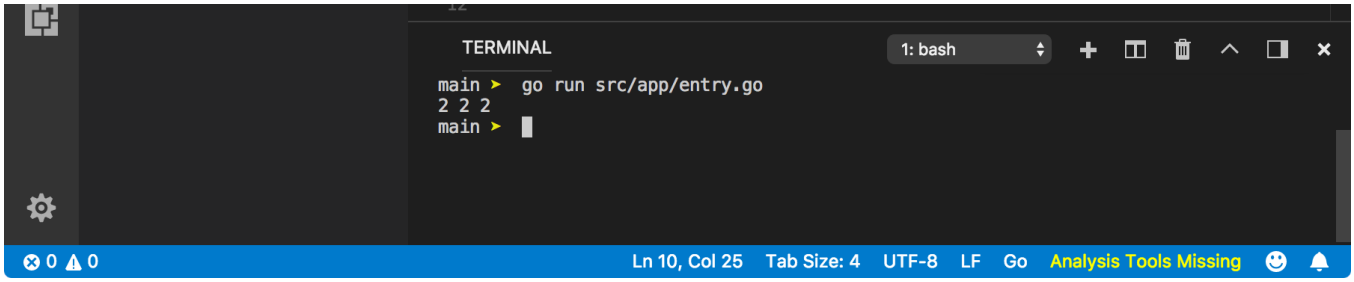


Variable initialization

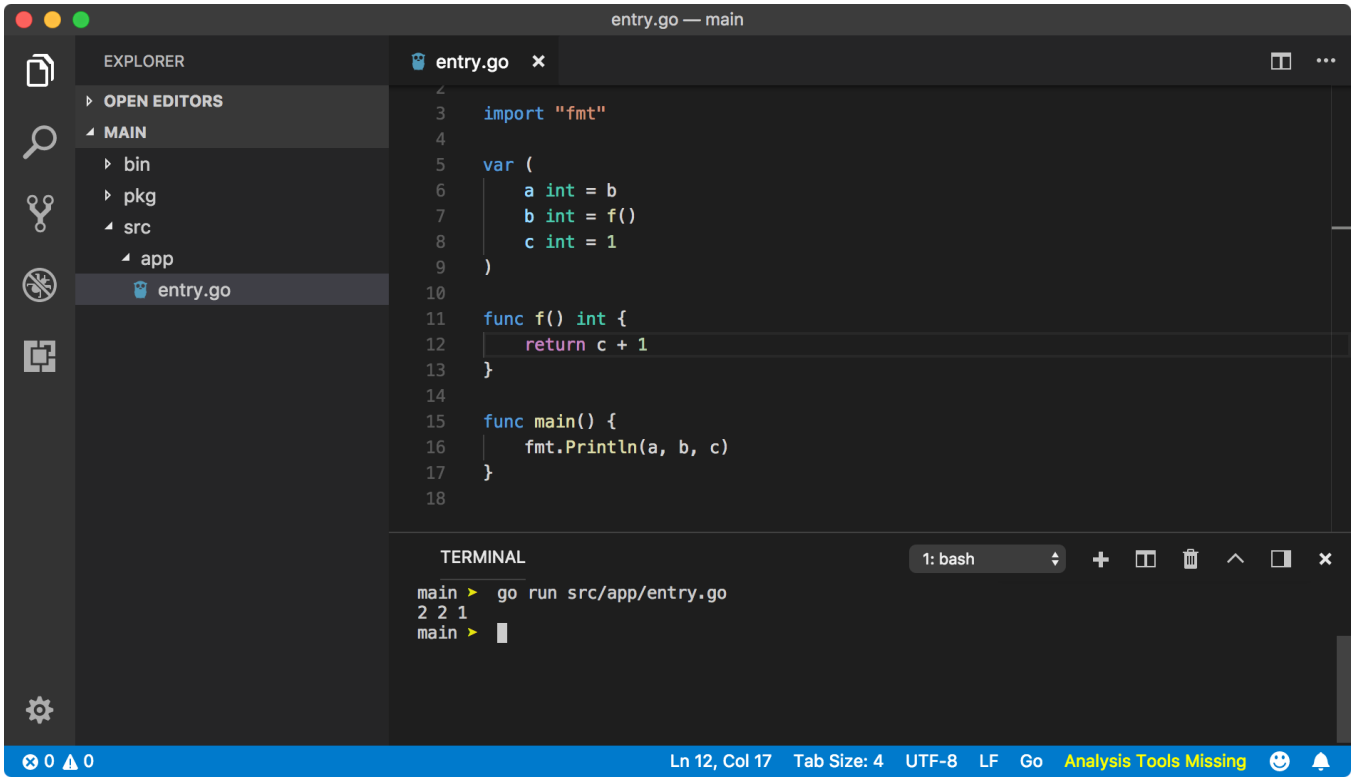
When a variable `a` depends on another variable `b`, `b` should be defined beforehand, else program won't compile. Go follows this rule inside functions.



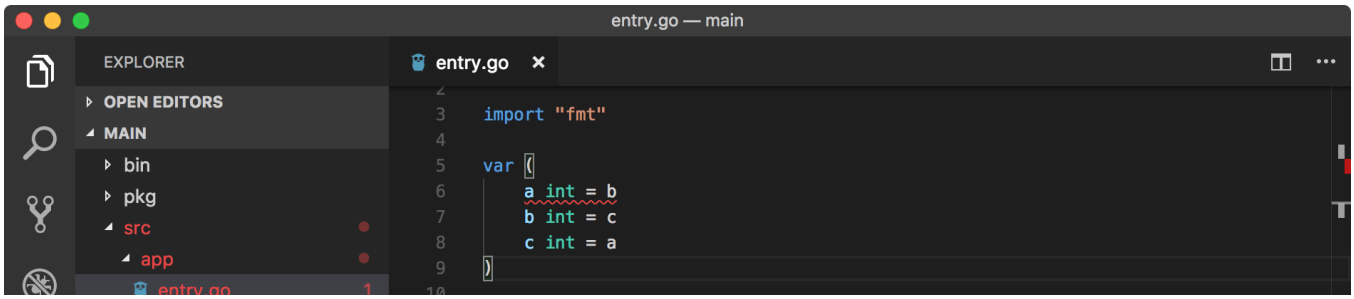
But when these variables are defined in package scope, they are declared in initialization cycles. Let's have a look at the simple example below.

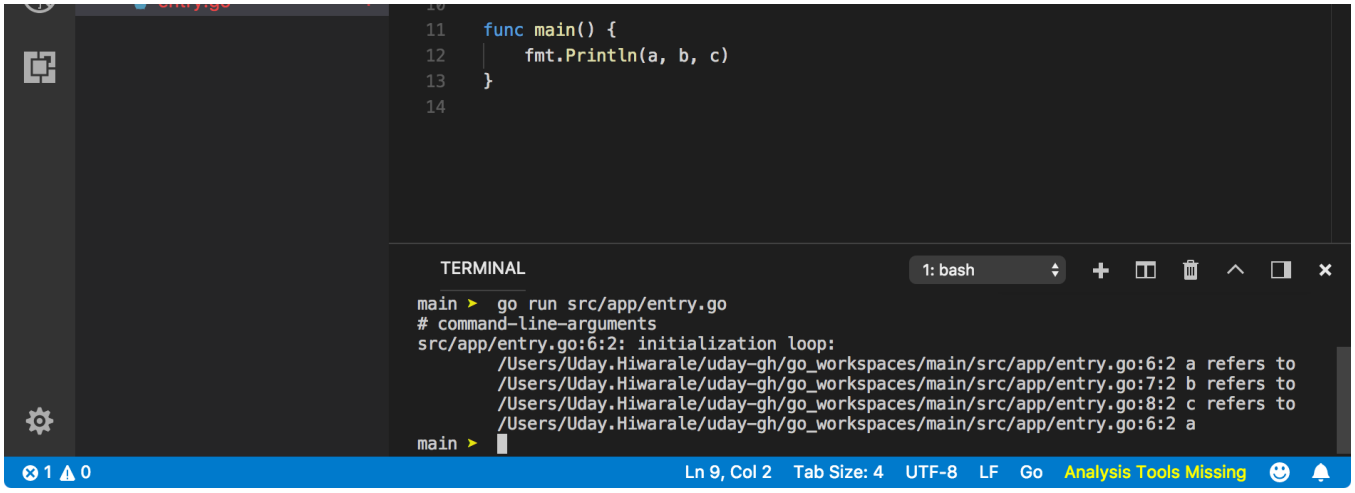


In the above example, first `c` is declared because its value is already declared. In later initialization cycle, `b` is declared, because it depends on `c` and value of `c` is already declared. In the final initialization cycle, `a` is declared and assigned to the value of `b`. Go can handle complex initialization cycles like below.

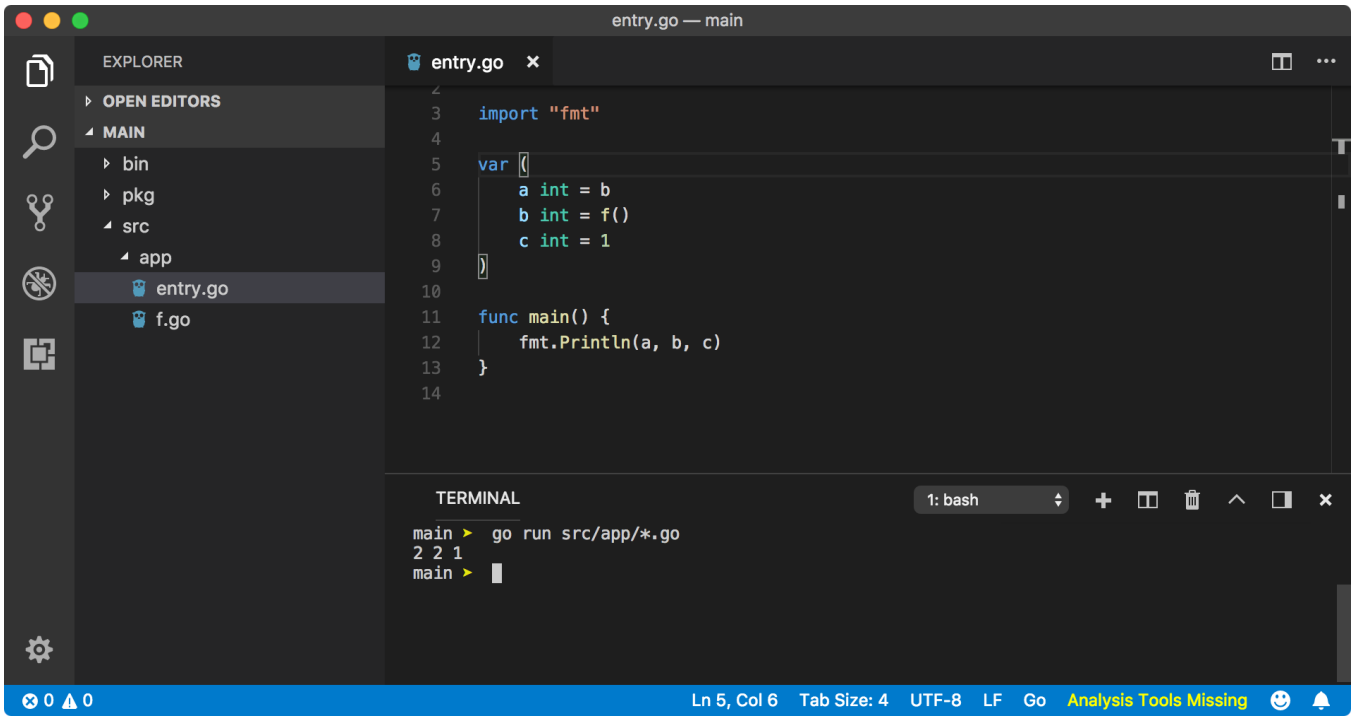


In the above example, first `c` will be declared and then `b` as it's value depends on `c` and finally `a` as its value depends on `b`. You should avoid any initialization loop like below where initialization gets into a recursive loop.



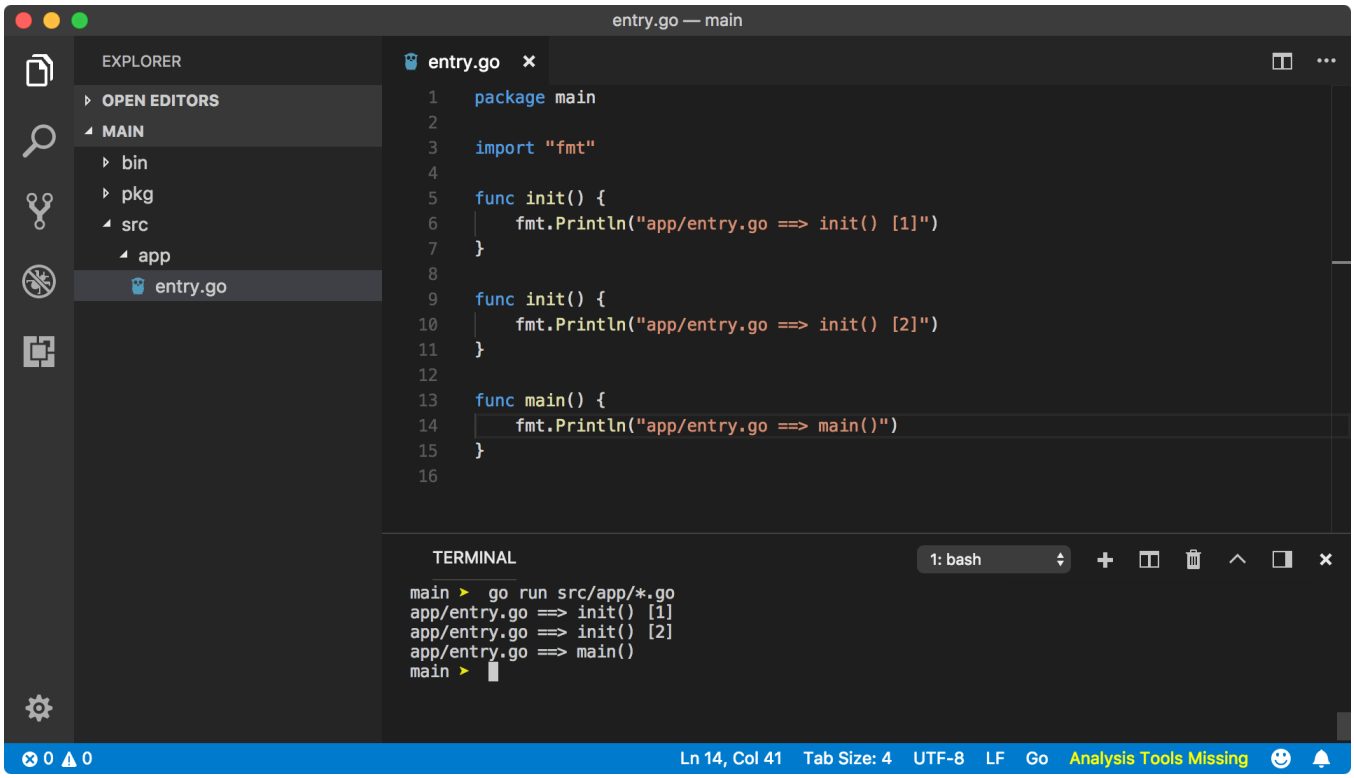


Another example of package scope would be, having a function `f` in a separate file which references variable `c` from the main file.

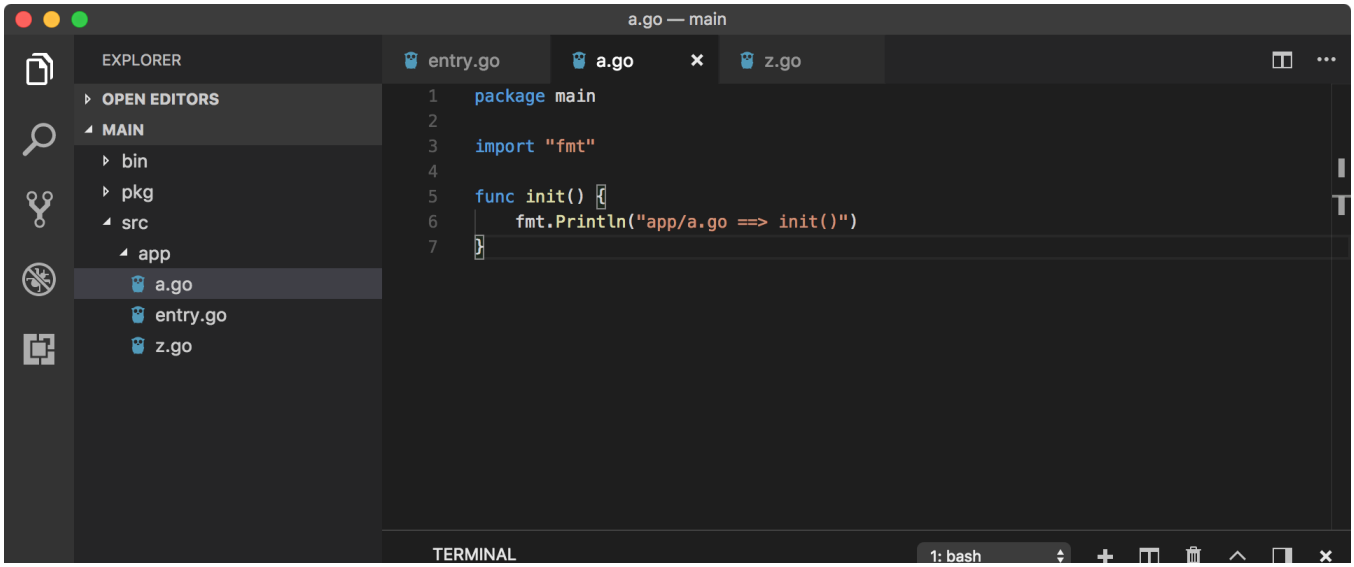


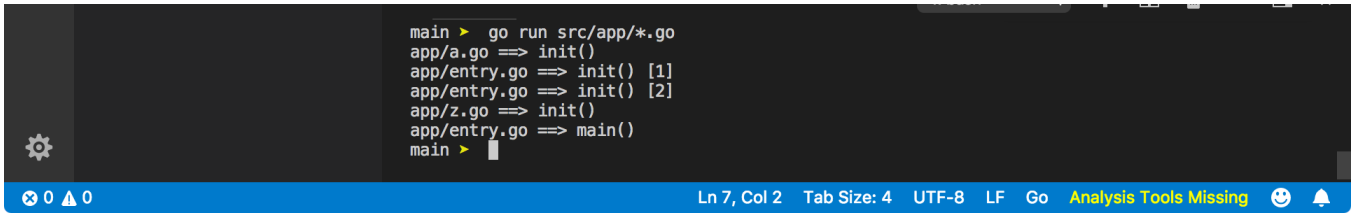
Init function

Like `main` function, `init` function is called by Go when a package is initialized. It does not take any arguments and doesn't return any value. `init` function is implicitly declared by Go, hence you can not reference it from anywhere (*or call it like* `init()`). You can have multiple `init` functions in a file or a package. Order of the execution of `init` function in a file will be according to the order of their appearances.

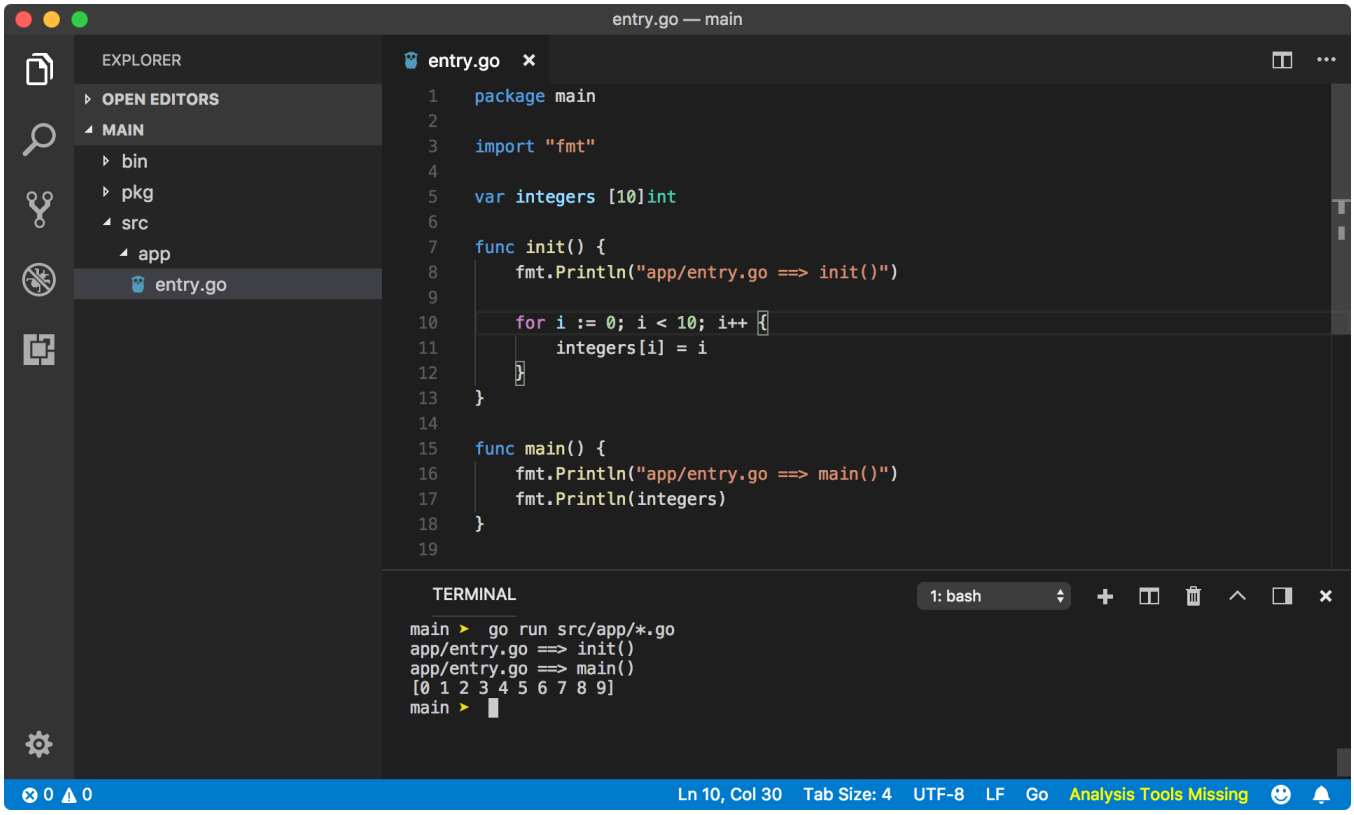


You can have `init` function anywhere in the package. These `init` functions are called in lexical file name order (***alphabetical order***).





After all, `init` functions are executed, `main` function is called. Hence, the **main job of `init` function is to initialize global variables** that cannot be initialized in the global context. For example, initialization of an array.



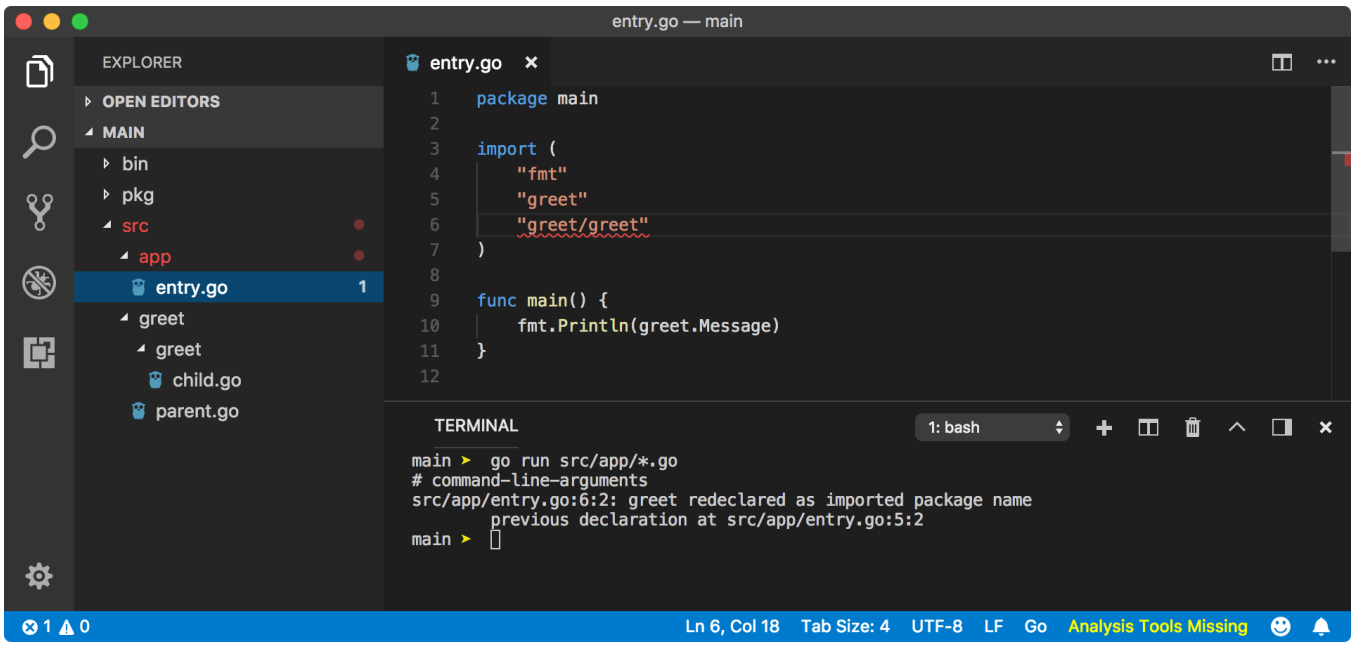
Since, `for` syntax is not valid in package scope, we can initialize the array `integers` of size `10` using `for` loop inside `init` function.

Package alias

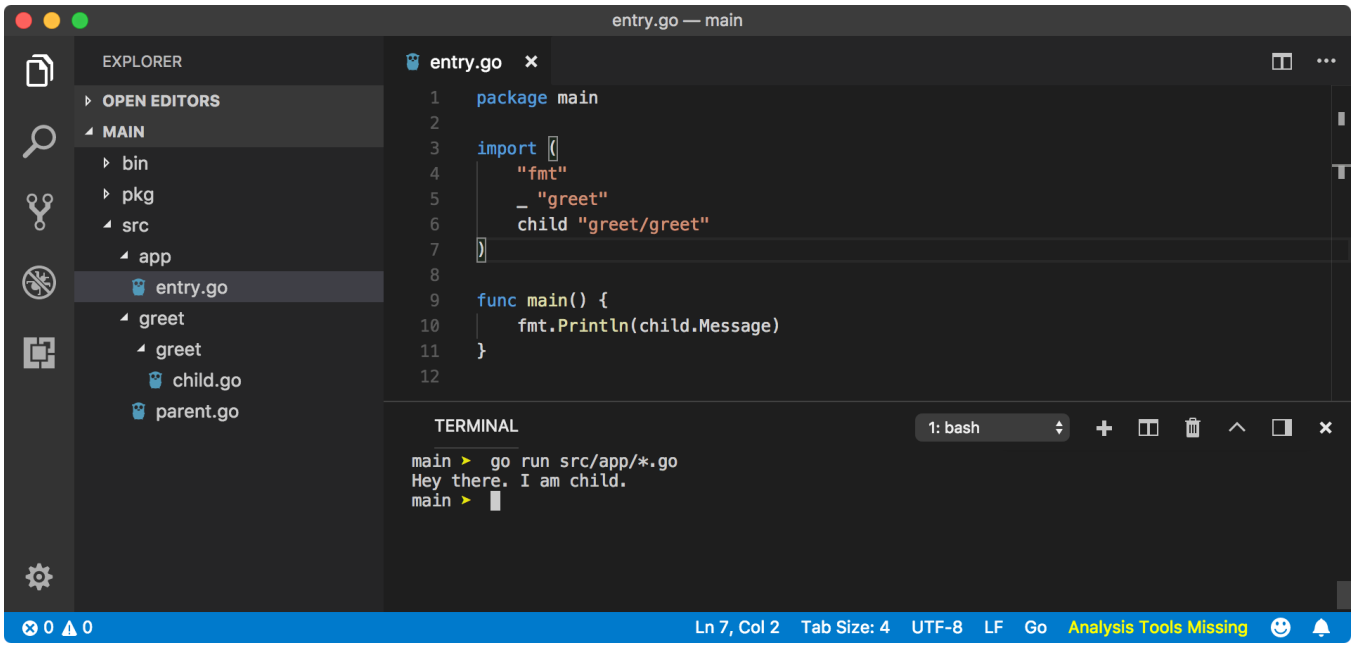
When you import a package, Go create a variable using the package declaration of the package. If you are importing multiple packages with the same name, this will lead to a conflict.

```
// parent.go
package greet
```

```
var Message = "Hey there. I am parent."

// child.go
package greet

var Message = "Hey there. I am child."
```



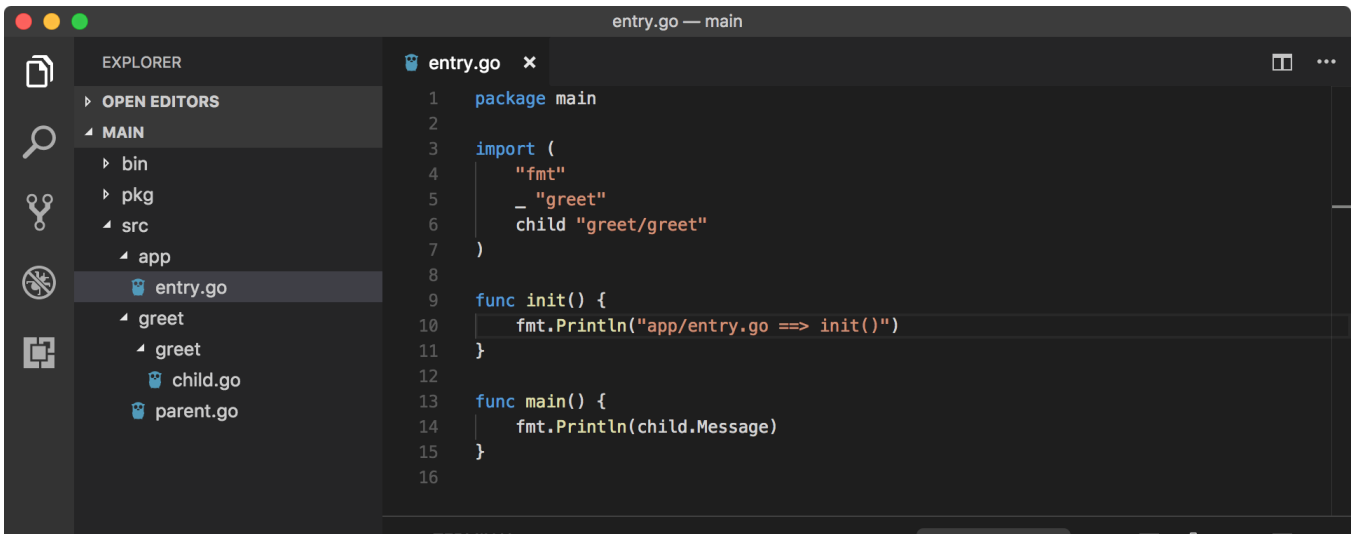
Hence, we use **package alias**. We state a variable name in between `import` keyword and package name which becomes the new variable to reference the package.

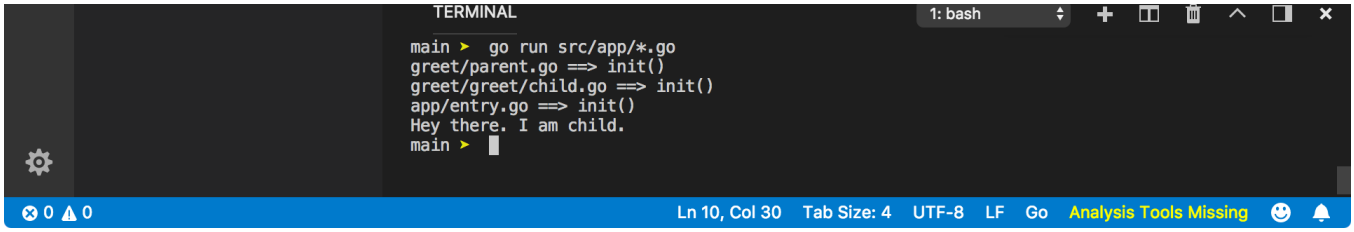


In the above example, `greet/greet` package now is referenced by `child` variable. If you notice, we aliased `greet` package with an underscore. Underscore is a special character in Go which acts as `null` container. Since we are importing `greet` package but not using it, Go compiler will complain about it. To avoid that, we are storing reference of that package into `_` and Go compiler will simply ignore it.

Aliasing a package with an **underscore** which seems to do nothing is quite useful sometimes when you want to initialize a package but not use it.

```
// parent.go
package greet

import "fmt"

var Message = "Hey there. I am parent."

func init() {
  fmt.Println("greet/parent.go ==> init()")
}

// child.go
package greet

import "fmt"

var Message = "Hey there. I am child."

func init() {
  fmt.Println("greet/greet/child.go ==> init()")
}
```





The main thing to remember is, **an imported package is initialized only once per package**. Hence if you have any import statements in a package, an imported package is going to be initialized only once in the lifetime of main package execution.

> *If we use* `.` *(dot) as an alias like* `import . "greet/greet"` *then all the export members of* `greet` *package will be available in the local file block scope and we can reference* `Message` *without using qualifier* `child`*. Hence,* `fmt.Println(Message)` *would work just fine. This type of import is called as* ***Dot Import*** *and Go community is* ***not very fond of it*** *as it can cause some issues.*

Program execution order

So far, we understood everything there is about packages. Now, let's combine our understanding of how a program initializes in Go.

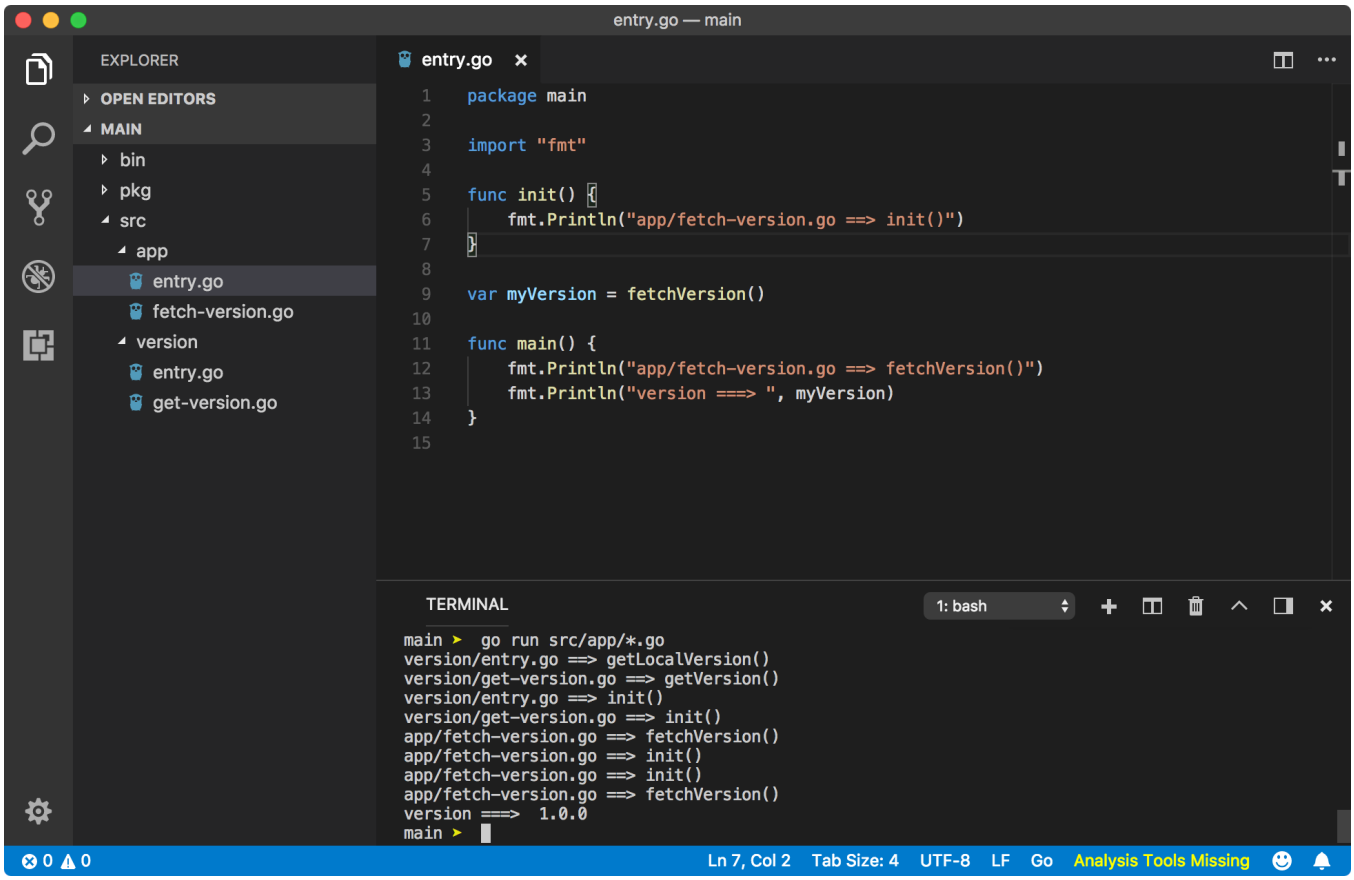
```
go run *.go
├── Main package is executed
├── All imported packages are initialized
|   ├── All imported packages are initialized (recursive definition)
|   ├── All global variables are initialized
|   └── init functions are called in lexical file name order
└── Main package is initialized
    ├── All global variables are initialized
    └── init functions are called in lexical file name order
```

Here is a small example to prove it.

```
// version/get-version.go
package version

import "fmt"
```

```
func init() {
 fmt.Println("version/get-version.go ==> init()")
}

func getVersion() string {
 fmt.Println("version/get-version.go ==> getVersion()")
 return "1.0.0"
}

/**************************/

// version/entry.go
package version

import "fmt"

func init() {
 fmt.Println("version/entry.go ==> init()")
}

var Version = getLocalVersion()

func getLocalVersion() string {
 fmt.Println("version/entry.go ==> getLocalVersion()")
 return getVersion()
}

/**************************/

// app/fetch-version.go
package main

import (
 "fmt"
 "version"
)

func init() {
 fmt.Println("app/fetch-version.go ==> init()")
}

func fetchVersion() string {
 fmt.Println("app/fetch-version.go ==> fetchVersion()")
 return version.Version
}

/**************************/

// app/entry.go
package main

import "fmt"
```

```
func init() {
 fmt.Println("app/entry.go ==> init()")
}

var myVersion = fetchVersion()

func main() {
 fmt.Println("app/fetch-version.go ==> fetchVersion()")
 fmt.Println("version ===> ", myVersion)
}
```



Installing 3rd party package

Installing a 3rd party package is nothing but cloning the remote code into a local `src/<package>` directory. Unfortunately, Go does not support package version or provide package manager but a proposal is waiting ***here***.

Since Go does not have a centralize official package registry, it asks you to provide hostname and path to the package.

```
$ go get -u github.com/jinzhu/gorm
```

Above command imports files from `http://github.com/jinzhu/gorm` URL and saves it inside `src/github.com/jinzhu/gorm` directory. As discussed in nested packages, you can import `gorm` package like below.

```
package main

import "github.com/jinzhu/gorm"

// use ==> gorm.SomeExportedMember
```

So, if you made a package and want people to use it, just publish it on GitHub and you are good to go. If your package is executable, people can use it as a command line tool else they can import it in a program and use it as a utility module. The only thing they need to do is use below command.

```
$ go get github.com/your-username/repo-name
```