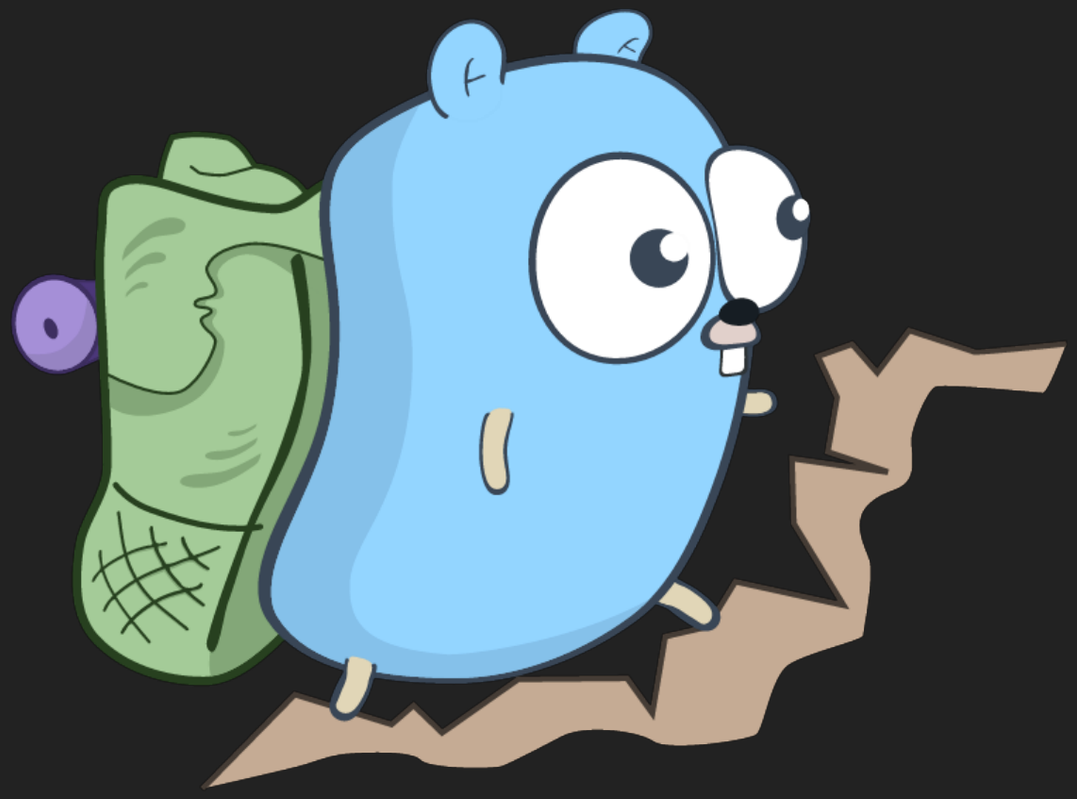
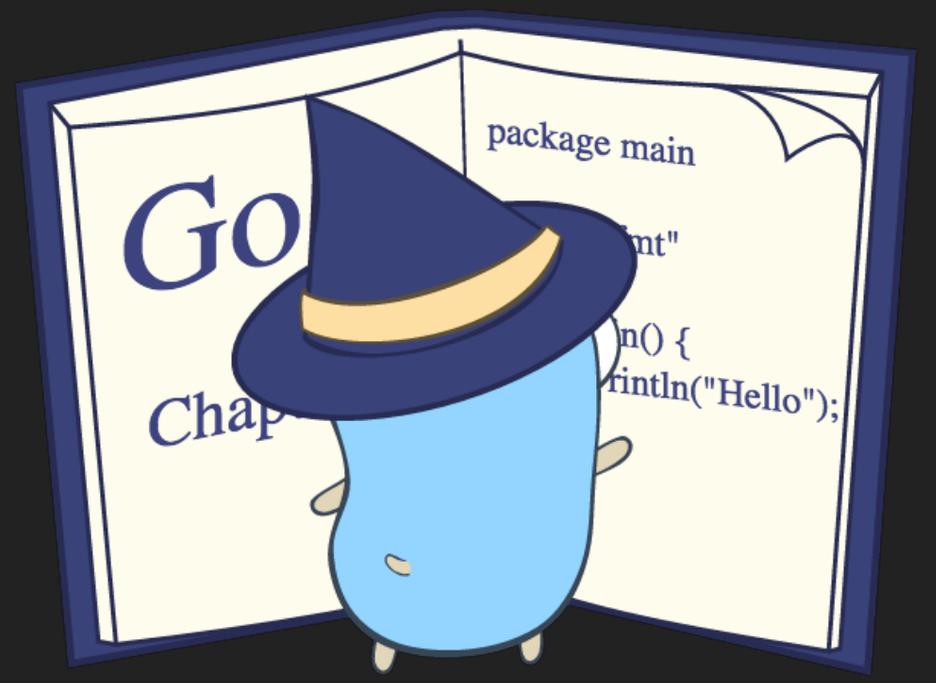




THE GO LANGUAGE BASICS

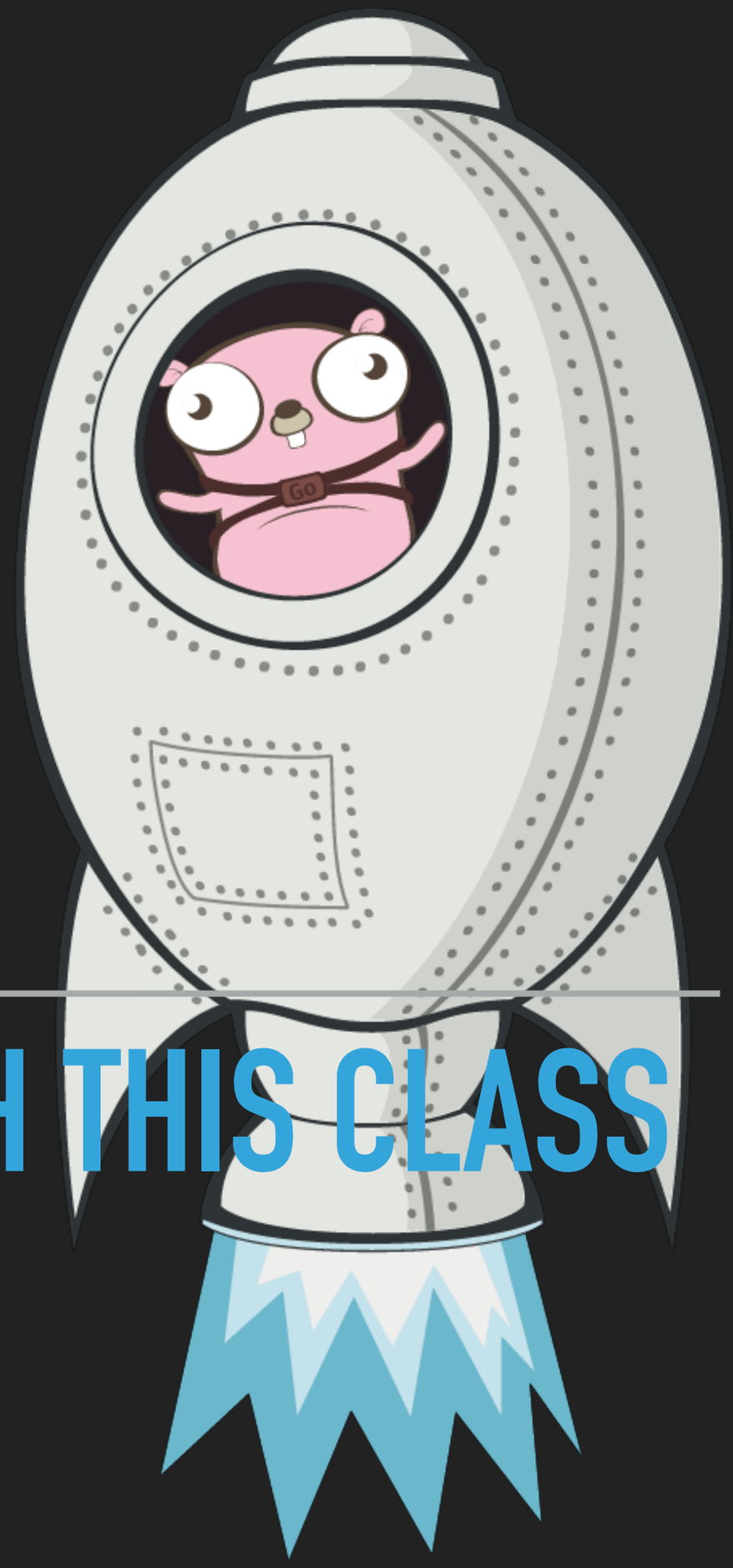
OR HOW TO BE MORE PRODUCTIVE AND HAVE FUN

WHAT THIS CLASS IS (AND ISN'T)

- This class is not an intro to programming class. We assume you understand certain concepts like variables, conditionals and loop statements.
- This class does not teach the Go programming environment (build tools, etc…). All programs here are designed to be run in the Go playground (http://play.golang.org). The Go programming environment is detailed by many others sources on the web.
- This class is for those who have experience with a scripting language (Python, Perl, Ruby, …)
- This class is not a comprehensive guide and does not always show the best way of completing a task. It is for bootstrapping students with needed material and the examples are used to teach concepts, not optimal methods.
- You like Gophers, because every Go presentation, conference, etc.. will be covered in them (including this one).

CLASS MATERIALS

- You will need a copy of the slides used in this class. These can be found at:
  - http://www.github.com/johnsiilver/go_basics/
    go_basics.pdf



WHY TO USE/NOT USE GO

OR WHY TO BOTHER WITH THIS CLASS

WHY USE GO

- Go is type-safe, preventing many errors common to non-typed languages. This alone will increase your productivity 10x and make refactoring much simpler.
- Go is fast with a simple concurrency model.
- Go has low memory consumption compared to interpreted languages (Java, Python, Perl).
- Go is compiled. No need to distribute different versions of the interpreter or virtual machine.
- Go is quick to learn with few concepts not found in interpreted languages.
- Go is garbage collected, allowing an engineer to work on their code, not on which pointer type to use and when to allocate on the stack/heap.
- Go is fun. After 5k lines of code, you won’t want to Go back (pun intended).

WHY USE GO

- Go builds FAST!

268,843 Lines of Go in 2,632 files

No warm cache

Pachyderm server(btw)

real 0m 33.70s

user 1m 33.04s

sys 1m 13.16s

With a warm cache:

real 0m 6.67s

user 0m 16.07s

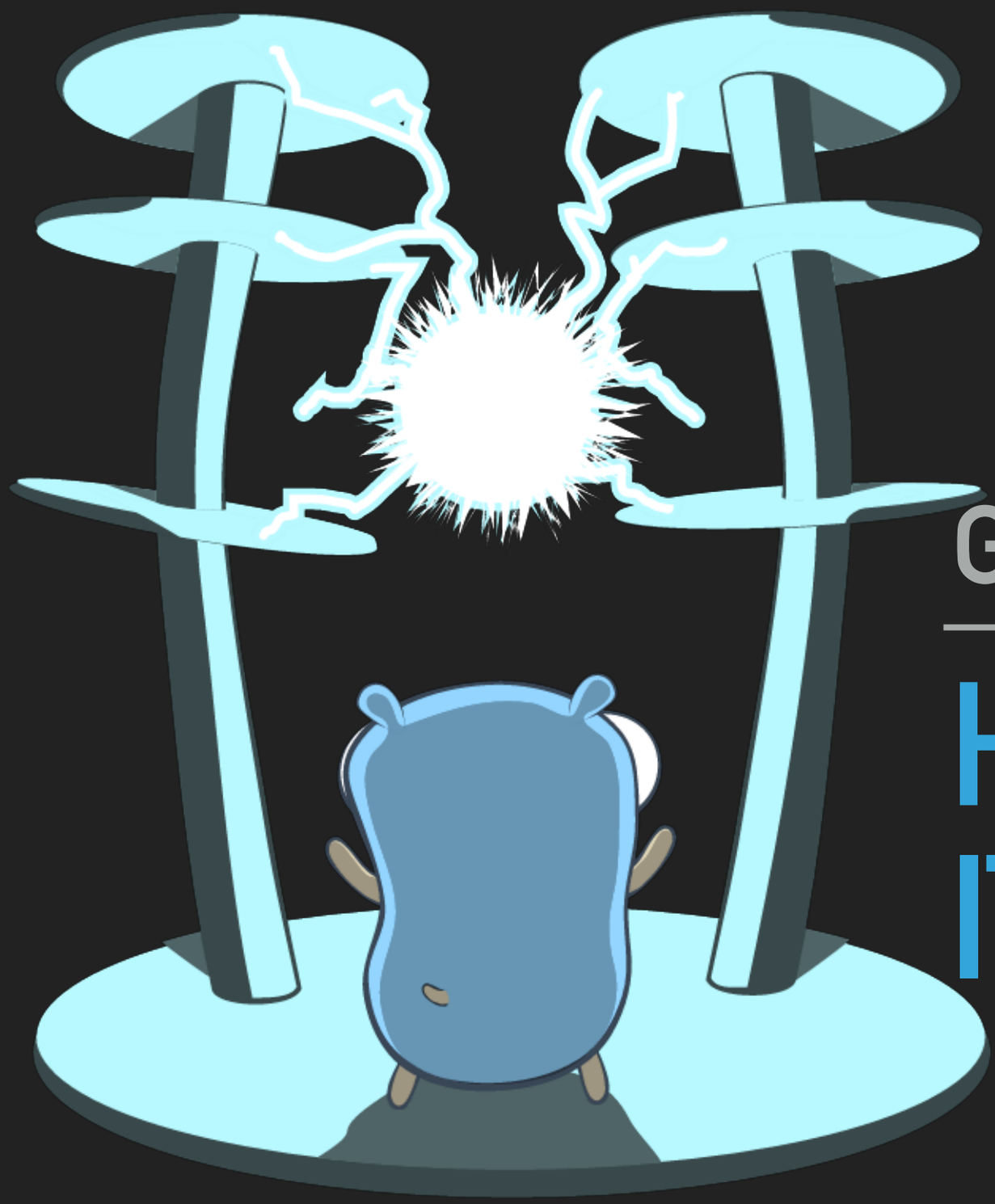
sys 0m 4.18s

WHY NOT TO USE GO

- Go is faster for large programs than interpreted languages or languages using virtual machines. It is not faster than languages such as C++. If every nano-second equals money, C or C++ is probably your best bet. But only if you are a good C/C++ developer.*
- Go is garbage collected. While this protects you from many mistakes that are common in C or C++, you no longer have control of when memory is freed and the GC adds delays when doing collection.
- While Go has a large and growing amount of software available for it, there are more libraries available for other languages.
- Go has virtually no UI tooling (outside of web frameworks) or an impressive IDE (like Visual Studio/ Xcode). If you are working on OS native user facing apps or with OpenGL/Direct X, Go is probably not the best choice (yet).
- The Go debugger situation is not stellar. While you can use the pproof debugger, it does not support the runtime. Third-party debuggers are not practical in many environments.

*This is likely to draw criticism because interpreted language X is faster on a micro benchmark. In practice, for a large program written by a good developer, Go is faster than Java, CPython, and Javascript based programs.

Note: I'm being fairly broad with the term "interpreted" to include virtual machine languages that are semi-compiled.



GO PACKAGES

HOW GO ORGANIZES ITS CODE

SOURCE FILES AND PACKAGES

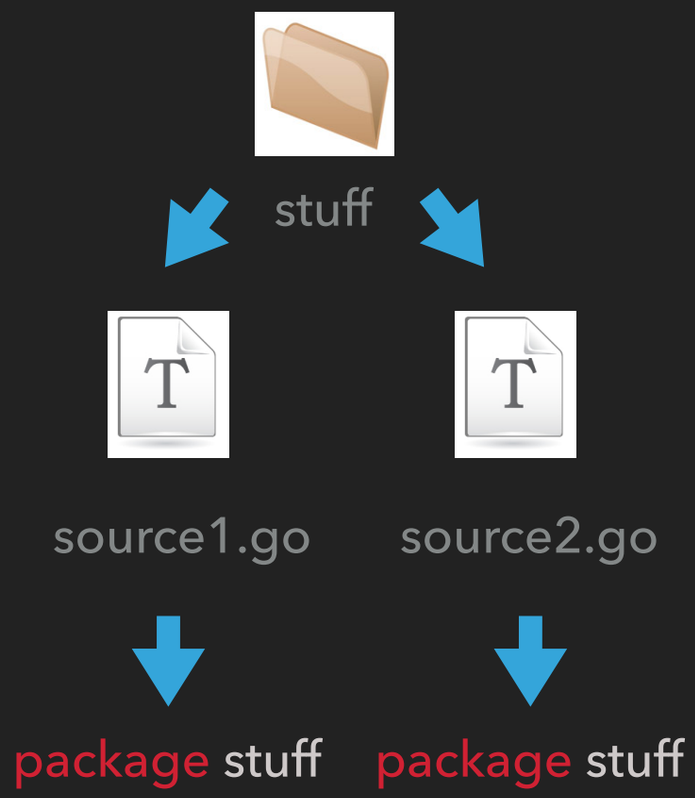
- Go source files are named <file name>.go
- All Go files in the same directory will belong to the same package.
- A package can be made up of multiple files in the same directory.

SOURCE FILES AND PACKAGES

- Package names are created using the package keyword followed by the package name at the top of the file.
- The package name must be the same as the directory.

SOURCE FILES AND PACKAGES

- Two files with different names in the same directory should have the same package name and belong to the same package.



SOURCE FILES AND PACKAGES

- Package main is special. Your directory does not have to be named “main” and it indicates where the compiler will compile a binary and not a library.
- Package main always contains a function called main(), which is the entrance point for execution. Similar to Python’s: if__name__ == ‘__main__':

```
package main

func main() {
  // Do something here.
}
```

SOURCE FILES AND PACKAGES

- Importing a package into another file is done with the import keyword.

```
package main

import "fmt"

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

Package fmt is part of the standard library

SOURCE FILES AND PACKAGES

- You can simplify multiple imports by using () with the import keyword.

```
package main

import (
  "fmt"
  "os"
)

func main() {
  fmt.Println("Hello World")
  os.Exit(1)
}
```

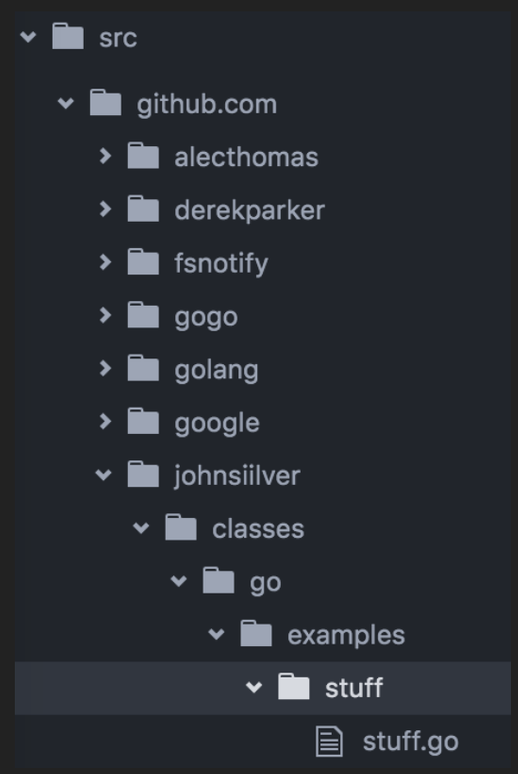
(This prevents having to type import again and again)

SOURCE FILES AND PACKAGES

- If you import a local package, the import statement is the path from your "src" directory (but not including it) to the directory containing the package.

```go
package main

import (
  "fmt"

  "github.com/johnsiilver/classes/go/examples/stuff"
)

func main() {
  fmt.Printf("%d\n", stuff.Add(2,2))
}
```

(The arrow points to the package name)



Directory structure to this package

SOURCE FILES AND PACKAGES

- The following is an example of a custom package providing a function to add two numbers together

```
package stuff

// Add returns the sum of x and y.
func Add(x, y int) int {
  return x + y
}
```

SOURCE FILES AND PACKAGES

- This is an example of a binary that imports the stuff package and prints out 2+2

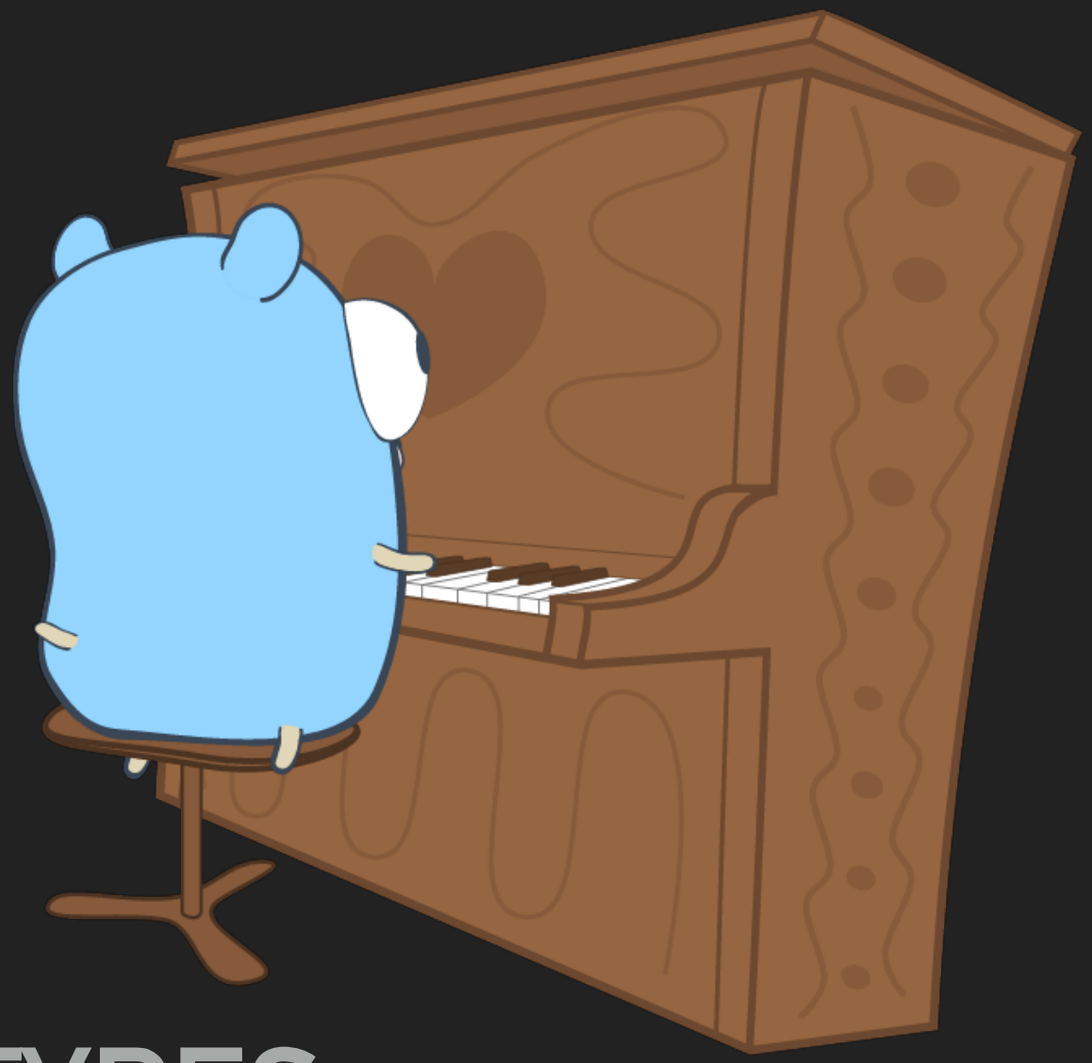
```go
package main

import (
  "fmt"

  "github.com/johnsiilver/classes/go/examples/stuff"
)

func main() {
  fmt.Printf("%d\n", stuff.Add(2,2))
}
```

SOURCE FILES AND PACKAGES

- Standard library packages can be found at:
  - http://golang.org/pkg
- A great source for third-party packages is:
  - https://godoc.org/

SUMMARY: SOURCE FILES AND PACKAGES

- Go source files are made up of files ending with .go
- Go code is divided into packages.
- All .go files in a directory should belong to the same package.
- The package name must be the same as the directory name.
- Packages are declared at the top of the file with:
  - package <package name>
- package main is special, it is the entrance point for an executable.



GO TYPES

EVERYONE HAS A TYPE

STATIC TYPING VS DYNAMIC TYPING

- Go uses static typing, meaning that once a variable has a type (string, int, float, ...), that variable can only store values of that type.

- Many languages have dynamic typing, meaning a variable can hold any type of value. One moment it is a string, the next it is an int.

- Static typing prevents errors in the compiler. You cannot store a string in a variable that has the int type. Dynamic typing is a large source of runtime errors.

STATIC TYPING VS DYNAMIC TYPING

- The following is an example of dynamic typing in Python
- x starts as an integer
- x ends as a string

```
def someFunc():
    x = 3
    print(x)
    x = "hello"
    print(x)
```

STATIC TYPING VS DYNAMIC TYPING

- At first this seems like an advantage, but various studies have show this to increase runtime errors.
- It is easy to send the wrong types to function than was actually meant, especially if the argument list gets long. Many of these errors will not be exposed until runtime.

```
def Add(x, y):
    return x + y
```

- You don’t know what x and y are going to be.
- What will be returned is unknown.
- This will work if x and y are integers or strings.
- It will traceback during runtime if called and x is and int and y is a string.

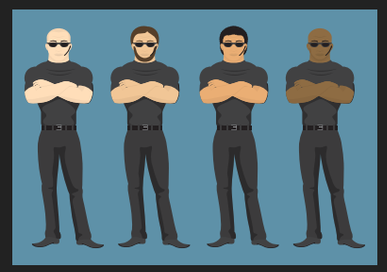
SO WHAT IS A TYPE

- A type defines what attributes data must possess to be placed in a variable.
- An int32 type states the data stored in it must have the following attributes:
  - Is a whole number
  - Must >= -2147483648
  - Must be <= 2147483647
- A string type states the data stored in it must have the following attributes:
  - Must contain UTF-8 characters (a character encoding standard)

SO WHAT IS A TYPE

People trying to get in an upscale bar

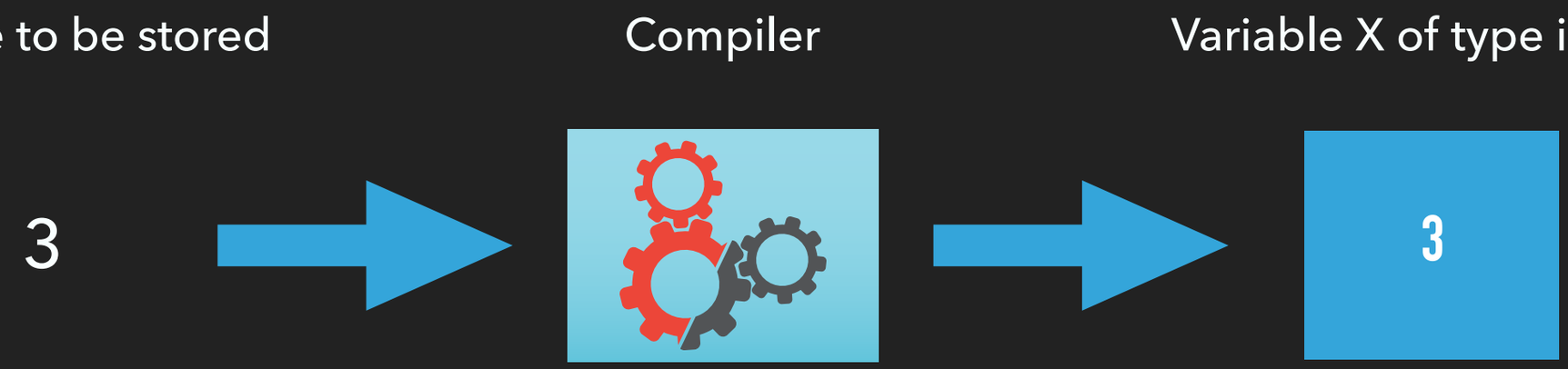
Bouncer



Upscale Bar

- Are you 21?
- Do you have the right attire?

SO WHAT IS A TYPE



- Is it a whole number?
- >= -2147483648
- <= 2147483647

SO WHAT IS A TYPE

- A variable of a type is incompatible with variables of other types:
  - For example, you cannot add an int and int64 together, even though on most platforms they have the same attributes.
- Once a variable is declared with its type, no data of any other type can be stored in it.
- Some types can be converted from one type to another type.

COMMON TYPES IN GO

- int - An integer that can be 32 or 64 bit, depending on the platform
- string - UTF8 character string
- slices - A growable Array holding a contiguous list of the same types of elements. Similar to Python lists or Ruby Arrays.
- maps - Like Python dictionaries or Perl hashes, stores key/value pairs. Keys must all be the same type and values must be the same type. Key type and value type can be different.
- Structs - Go's class like type. Similar to Python classes or C structs. Holds a collection of named attributes.

NUMERIC TYPES IN GO (FOR REFERENCE)

- uint8 the set of all unsigned 8-bit integers (0 to 255)
- uint16 the set of all unsigned 16-bit integers (0 to 65535)
- uint32 the set of all unsigned 32-bit integers (0 to 4294967295)
- uint64 the set of all unsigned 64-bit integers (0 to 18446744073709551615)

- int8 the set of all signed 8-bit integers (-128 to 127)
- int16 the set of all signed 16-bit integers (-32768 to 32767)
- int32 the set of all signed 32-bit integers (-2147483648 to 21447483647)
- int64 the set of all signed 64-bit integers (-9223372036854775808 to 9223372036854775807)

- float32 the set of all IEEE-754 32-bit floating point numbers
- float64 the set of all IEEE-754 64-bit floating point numbers

- complex64 the set of all complex numbers with float32 real and imaginary parts
- complex128 the set of all complex numbers with float64 real and imaginary parts

- uint either 32 or 64 bit number (platform dependent)
- int either 32 or 64 bit number (platform dependent)

REFERENCE TYPES*

- slices - A growable array.
- maps - Key/Value pairing.
- channels - A synchronization primitive for communicating between goroutines (Go's answer to threads).

*Note: What makes a reference type different than other types will be discussed later

OTHER TYPES

- byte - An alias for uint32
- rune - An alias for int32, represents a Unicode code point
- uintptr - An unsigned integer large enough to store the interpreted bits of a pointer value
- array - A sequence of elements of a single type. Fixed in length.
- pointer type - Denotes the set of all pointers to variables of a given type, called the base type of the pointer.
- function type - A function type denote the set of all functions with the same parameters and result types.
- interface type - Specifies a method set that a variable must provide.

ZERO VALUE OF TYPES

Go provides that if the value of a variable is not declared, the value for the variable is set to the "Zero Value".

- Booleans will be set to false
- Integers will be set to 0
- Floats will be set to 0.0
- String will be set to ""
- Pointers, functions, interfaces, slices, channels and maps will start with the value of nil.

VARIABLES

HUH, WHAT ARE THEY GOOD FOR, ABSOLUTELY EVERYTHING

-EDWIN STARR

DECLARING A VARIABLE

- Variables are declared using the var keyword.
  - var x int, declares variable x and sets its type as an int.
- You can declare the initial value during variable declaration.
  - var x int = 7
- If you omit the type, Go will assign a type. Integers are commonly set to the int type.
  - var x = 7
- When inside a function, this can shortened via the := operator. This says, “create a variable and assign the initial value”.
  - x := 7 and var x = 7 are equivalent.
  - y := “hello world” and var y = “hello world” are equivalent.

Yes

```
x := 7
x = 3
```

~~No~~

```
x := 7
x := 3
```

DECLARING BASIC TYPES

```
// Declaring variables with the var keyword.
var x int
x = 7

var y string = "Hello World"

var z int = 7
var a = 7

// Declaring the same variables using :=
x := 7
y := "Hello World"
x = 12   // Why not := ???

// Declaring using := for a specific numeric type.
x := int64(7)

// Declaring multiple variables of the same type.
var a, b, c int = 3, 2, 1

// Declaring different variables, but using only one "var" keyword.
var (
  x float64
  y string = "Hello World"
  z uint32
)
```

EXERCISE

- Create a variable called x of type int with a value of 7 using the var keyword inside main().
- Create a variable called color of type string with a value of “yellow” using the := operator.
- Print out x and color using fmt.Println()
- Assign x the value of 10.
- Print out x.
- Answer at: https://play.golang.org/p/xr22BAZuqj

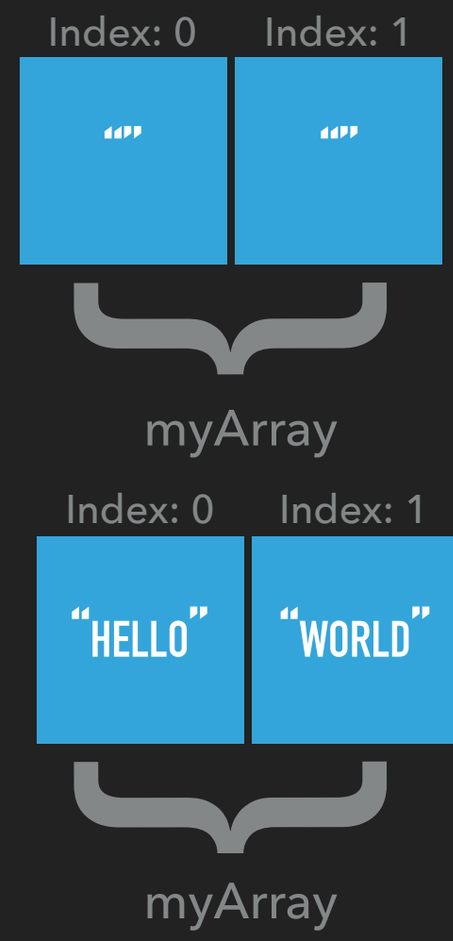
ARRAYS

- Rarely used, but important to understand.
- Arrays are a sequence of the same type of elements.
- Each entry in an array has an index, starting at 0.
- var x [2]string declares an array of 2 string elements.
- Arrays cannot be resized.
- Useful in understanding how a slice works.

ARRAYS

```
var myArray [2]string
```

Creates this in memory




```
myArray[0] = "Hello"
myArray[1] = "World"
```

Stores this in memory


```
fmt.Println(myArray[0])
fmt.Println(myArray[1])
```

Prints this to the screen

```
Hello
World
```

```
myArray[2] = "Won't work"
```

Gives compiler error

invalid array index 2 (out of bounds for 2-element array)

REFERENCE TYPES

- Three special reference types:
  - Slices
  - Maps
  - Channels
- Reference types are created with the make command. ONLY reference types are made with make.

SLICES

- Slices are a sequence of values like arrays.
- Each value is stored at an index starting at 0.
- Slices, unlike arrays, can grow in size using the append() command.
- Slice data is actually stored in an array.
- Slices are views into an array, but do not store the underlying data itself.

SLICES

```
mySlice := make([]string, 1, 2)
```

The slice length

The slice's array capacity

→ Creates →


```
mySlice[0] = "Hello"
```

→ Results in →

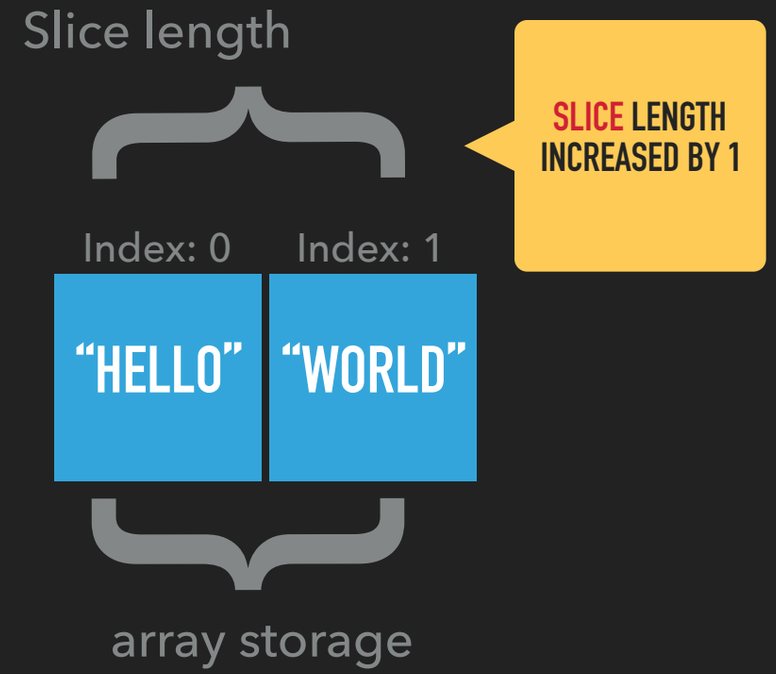

```
mySlice[1] = "World"
```

→ Results in → panic: runtime error: index out of range

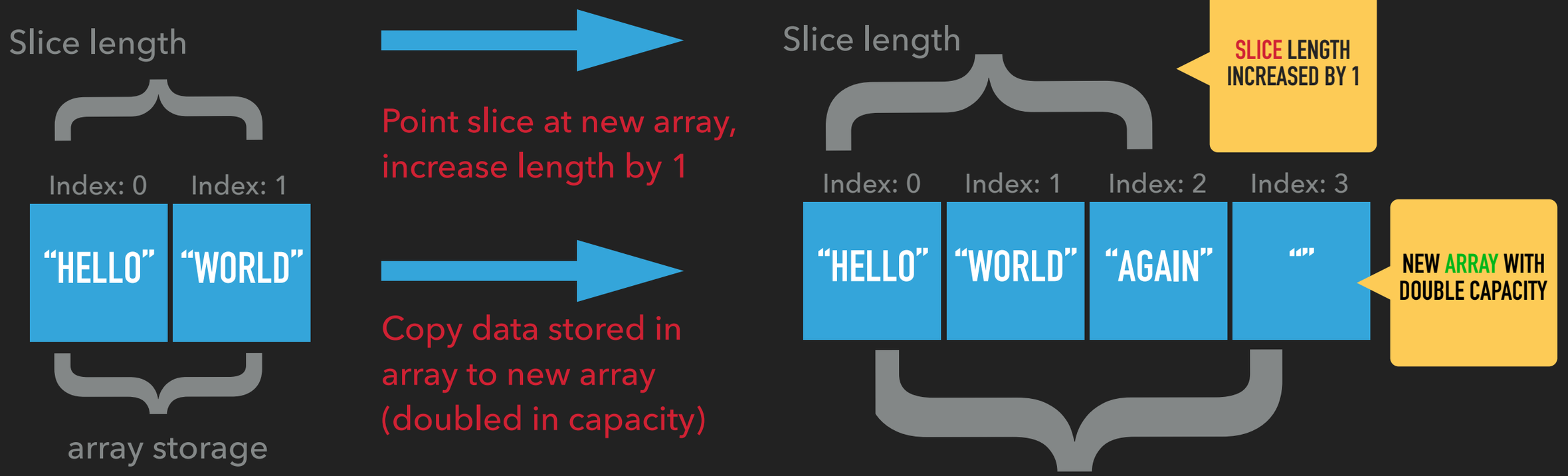
SLICES

```
mySlice = append(mySlice, "World")
```

Results in



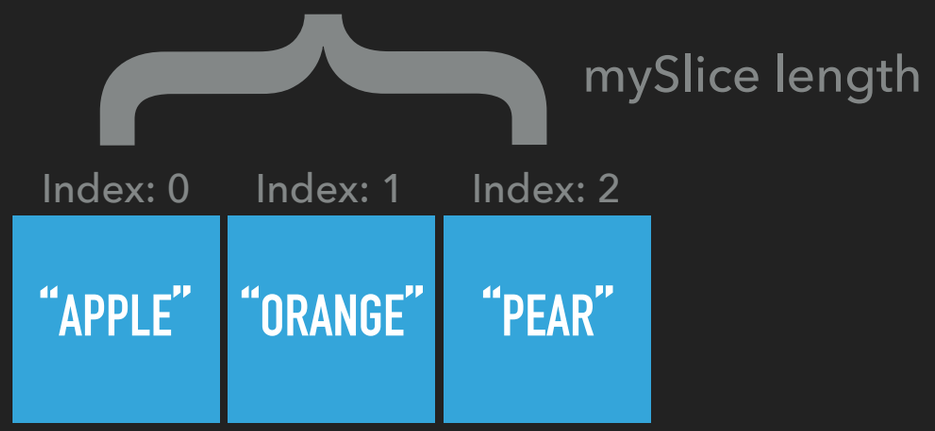

```
mySlice = append(mySlice, "Again")
```



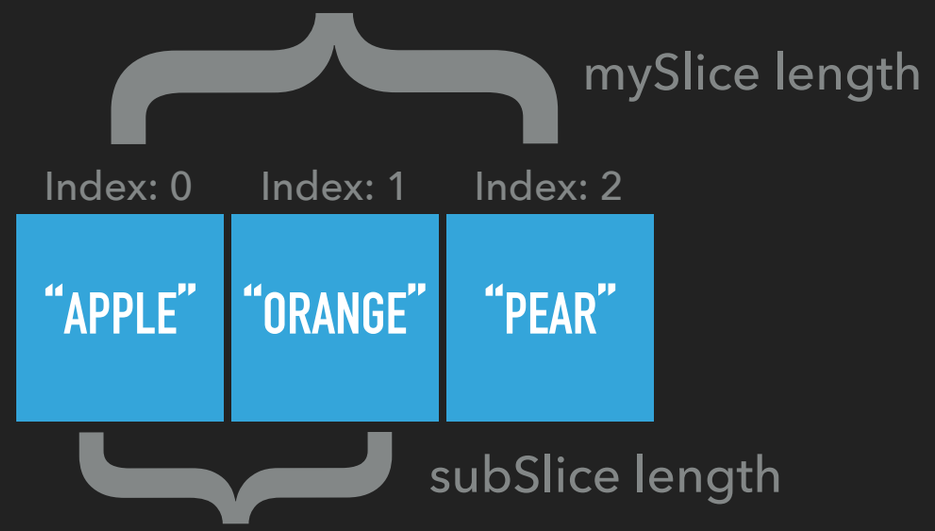
SLICES

- You can create a new slice that has a different view of the data in another slice.

```
mySlice := make([]string, 0)
mySlice = append(mySlice, "apple")
mySlice = append(mySlice, "orange")
mySlice = append(mySlice, "pear")
```



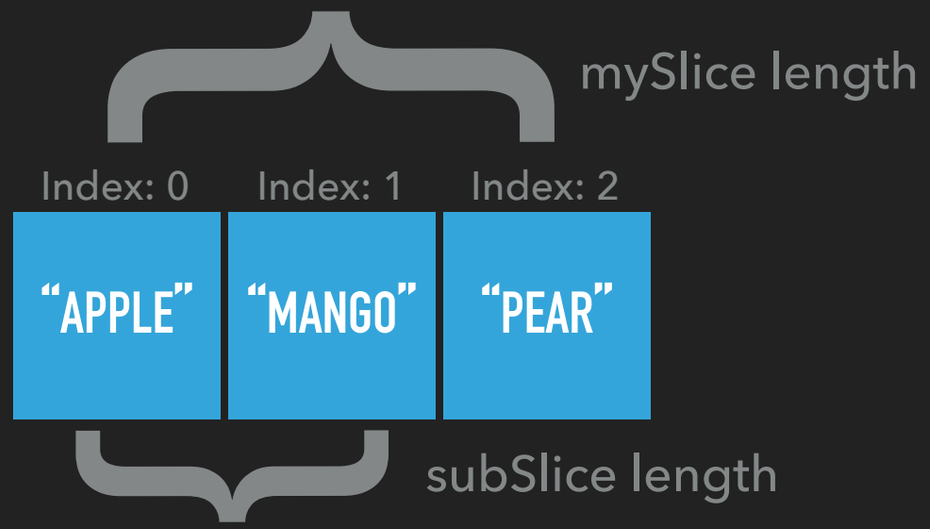

```
subSlice = mySlice[0:2]
```



SLICES

```
subSlice[1] = "mango"
```

→ Changes the underlying array →




```
fmt.Println(subSlice[1])
fmt.Println(mySlice[1])
```

→ Prints this to the screen →

```
mango
mango
```

```
subSlice[2]
```

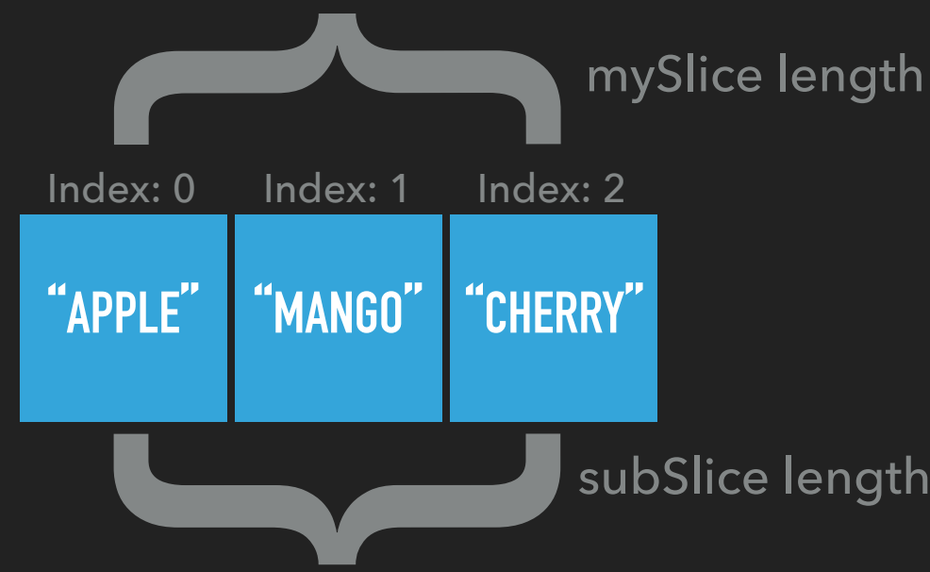
→ Results in → panic: runtime error: index out of range

SLICES

- Appending to the subSlice will change mySlice

```
subSlice = append(subSlice, "cherry")
```

→ Changes the underlying array and subSlice length →




```
fmt.Println(subSlice[2])
fmt.Println(mySlice[2])
```

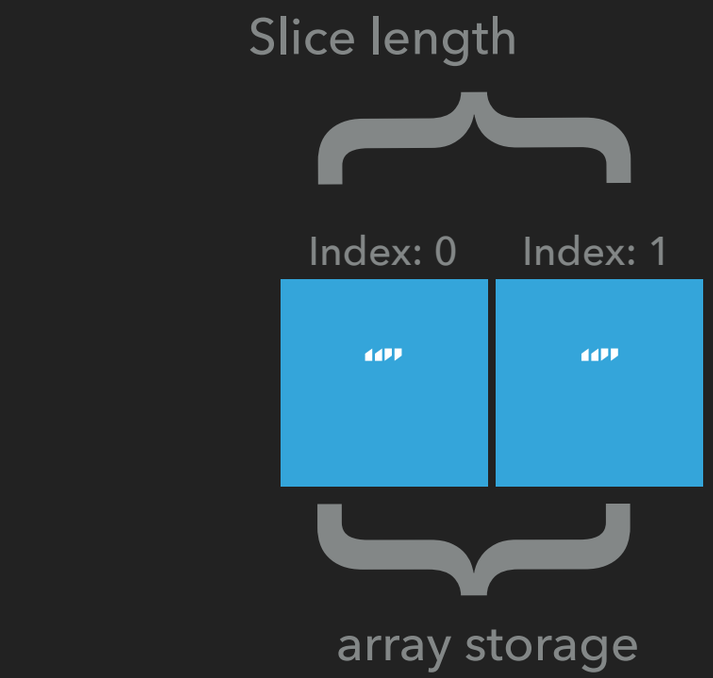
→ Prints this to the screen →

```
cherry
cherry
```

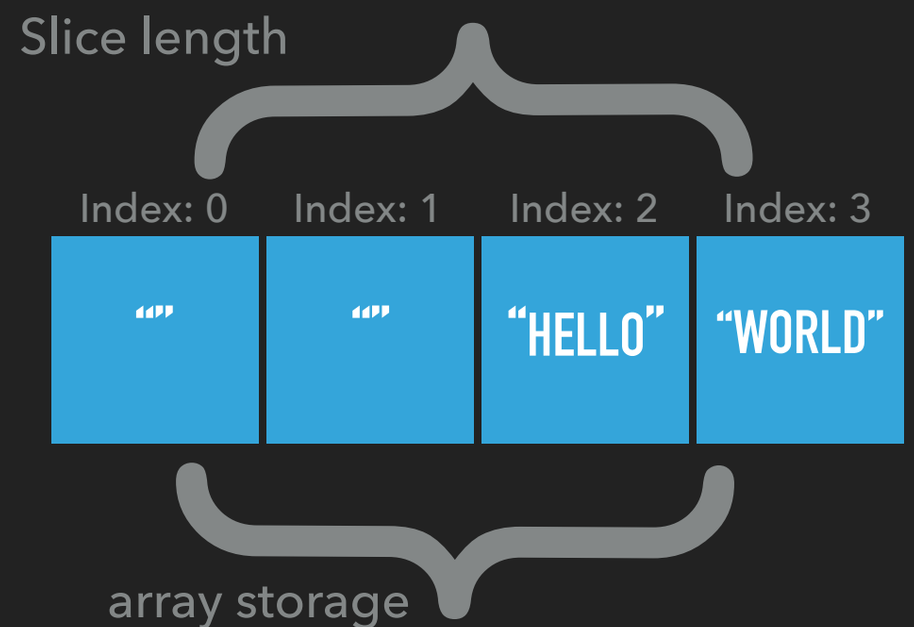
SLICE GOTCHAS

- Using make() for a slice with only one number following it will create the length and capacity the same

```
mySlice := make([]string, 2)
```



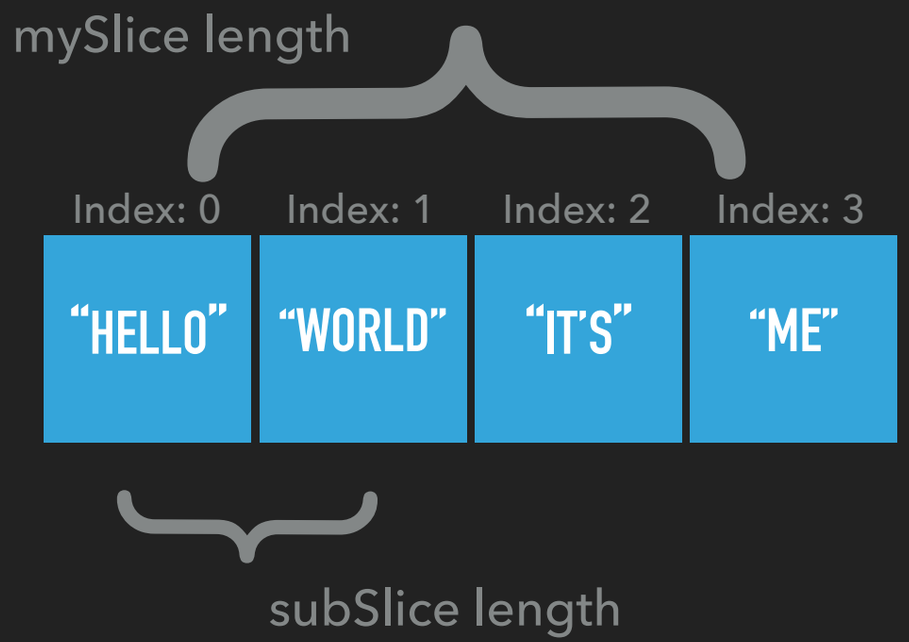

```
mySlice = append(mySlice, "hello", "world")
```



SLICE GOTCHAS

- subSlice = mySlice[0:2] includes index 0 and 1, NOT 2

```
subSlice = mySlice[0:2]
```



EXERCISE

- Create a variable called fruits of type []string
- Add the following values to fruits: “apple”, “orange”, “mango”
- Print out the value at index 1 using fmt.Println().
- Create a new slice called californiaFruits that is a slice of fruits containing only “apple” and “orange”.
- Print californiaFruits using fmt.Printf(“%#v\n”, californiaFruits)
- Answer at: https://play.golang.org/p/e6QDM7XqVY

MAPS

- Maps are key/value pairs that can be used for quick lookups.
- Maps are declared using the map keyword.
- myMap := make(map[string]int) declares a map with keys that are strings and values that are ints.
- myMap[“apple”] = 1, creates a key “apple” with a value of 1.
- myMap[“apple”] will return 1.

MAPS

```go
// Creates a map with keys that are strings, values that are int.
employeeID := make(map[string]int)

// Assign key "john" to value 0.
employeeID["john"] = 0

// Assign key "bill" to value 1.
employeeID["bill"] = 1

// Print out Bill's employee id.
fmt.Println(employeeID["bill"])

// Printing out a non-existing key will provide the value's Zero Value.
fmt.Println(employeeID["kate"])
```

Note: There is a way to detect if a key exists in a map. We will talk about it after if statements.

MAPS: A FEW NOTES

- Maps can pre-allocate storage similar to a slice to prevent copying data when new data is added.
- myMap := make(map[string]int, 10) indicates that underlying storage should be able to hold 10 values.
- There is no length declaration as there is in slices.
- Maps are stored in random order. Printing maps out in a loop may result in different ordered items.

EXERCISE

- Create a variable called modelToVendor of type map[string]string.
- Add the following value pairs to modelToVendor:
  - “focus”: “ford”
  - “prius”: “toyota”
- Print out the value at key “prius” using fmt.Printf()
- Answer at: https://play.golang.org/p/TropD-RsiU

COMPOSITE LITERALS

- Composite literals are a quick method to create reference types, arrays or struct types that contain pre-defined values.

```go
// Composite literal declaring an empty slice of strings.
mySlice := []string{}

// Composite literal declaring a slice of length 3 and capacity 3 storing
// the value "apple" in index 0, "orange" in index 1, and "pear" in index 2.
mySlice := []string{"apple", "orange", "pear"}

// Composite literal declaring an empty map.
myMap := map[string]string{}

// Composite literal declaring a map with keys and associated values.
myMap := map[string]string{
  "key0": "value0",
  "key1": "value1",
  "key2": "value2",
}
```

EXERCISE

- Create the modelToVendor of type map again, but use a composite literal.
- Create the fruits slice again, but use a composite literal.
- Print out the vendor for the “prius” again using fmt.Printf().
- Print out the entire slice of fruits using fmt.Printf().
- Answer at: https://play.golang.org/p/rpZddejV-r

LOOPS

THERE CAN BE ONLY ONE!

FOR LOOP – THE ONLY LOOP

- Go only has one type of loop, the for loop.
- The for loop syntax is:
  - for [init statement]; [conditional]; [post statement] {
    - for x := 0; x < 10; x++ {}
- The [init statement] happens only once, on the entrance into the loop. Above, it creates a variable x of type int with the value of 0.
- The [conditional] is checked to see if it evaluates to true on every loop. If it is true, the loop continues, if not, the loop ends. Above, the loop will continue until x is equal to or greater than 10.
- The [post statement] is executed when a loop is completed before checking the [conditional] on the start of a new loop. Above, the loop will increment x by 1 at then end of every loop.

FOR LOOP

```go
for x := 0; x < 10; x++ {
   fmt.Println("hello")
}
```

```
hello
hello
hello
hello
hello
hello
hello
hello
hello
hello
```

FOR LOOP

- A for loop can also act as a while loop in other languages by omitting the [init statement] and the [post statement].

```
x := 0
for x % 2 == 0 {
  fmt.Println("hello")
  x++
}
```

- The above loop will continue as long as the remainder of x divided by 2 is 0. So this will loop exactly one time.
- % returns the remainder of a number divided by a number. % is called the modulus operator.

FOR LOOP

- A for loop can be infinite by eliminating all statements.

```
for {
  fmt.Println("hello")
}
```

- The above loop will continue forever.
- You can use the term break inside a loop to end a loop.
- You can use the term continue inside a loop to stop the current loop execution and start from the top. This will still execute the [post statement].

EXERCISE

- Use a for loop to print from 1 to 100 (but not 0).
- Answer at: https://play.golang.org/p/O6lj_wfla3

FOR LOOP WITH RANGE

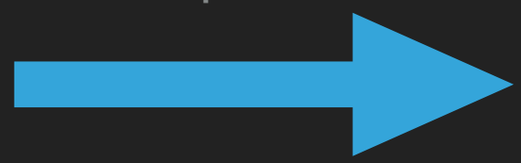
- range lets you extract key/value from maps, index/values from slices/arrays, and output from channels in a loop.
- range is always used on the same line as for.
- range output depends on the type you are extracting from.

FOR LOOP WITH RANGE

- When looping through slices/arrays, range has the following syntax:
  - for <index>, <value> := range <slice variable> {}

```
slice := []string{"a", "b", "c"}
for index, value := range slice {
  fmt.Printf("%d: %s\n", index, value)
}
```

Output



```
0: a
1: b
2: c
```

FOR LOOP WITH RANGE

- When looping through maps, range has the following syntax:
  - for <key>, <value> := range <map variable> {}

```
m := map[string]string{
  "a": "apple",
  "b": "banana",
}
for key, value := range m{
  fmt.Printf("%s: %s\n", key, value)
}
```

Output

```
b: banana
a: apple
```

Order is non-deterministic

FOR LOOP GOTCHA

- When doing loops, you may not want to use the index or the value.
- Go requires that if you declare a variable, you must use it or you get a compiler error.
- To solve this, you may use the _ character in place of a variable name to indicate you wish to ignore the returned value.
  - for _, <value> := range <map/slice variable> {}
    - This will ignore the key/index of the slice or map
- If you only want the keys or indexes in a loop, it is customary to use another loop format:
  - for <key/index variable> := range <map/slice variable> {}
    - Omitting the second variable will produce just the key or index.

EXERCISE

- Create a for loop that prints out the following slice of names: “bob”, “ann”, “marie”, “steve”.
- Create a for loop that prints out the following map key/values: 0: “john”, 1: “mary”, 2: “stevie”.
- Answer at: https://play.golang.org/p/CgbJ8meBd2

CONDITIONALS

GOTTA HAVE CHOICES

IF/ELSE

- The if statement is your basic conditional statement.
- if comes in two forms:
  - if [conditional] {}

```
if x < 10 {
  fmt.Println("x is less than 10")
}
```

  - if [statement]; [conditional] {}

```
if x := y + z; x < 10 {
  fmt.Println("x is less than 10")
}
```

IF/ELSE

- The if can be combined with else if and else to handle multiple choices.
- else and else if MUST be on the same line as a closing bracket }. It cannot be on a separate line as in some languages.

```
if x < 10 {
   fmt.Println("x is < 10")
}else if x == 11 {
   fmt.Println("x is 11")
}else {
   fmt.Println("x is > 11")
}
```

SWITCH

- The switch statement is a more advanced if/else statement.
- switch comes in a number of forms:

```
switch [value] {
case [match]:
  [statement]
case [match], [match]:
  [statement]
  [statement]
default:
  [statement]
}
```

Example

```
switch x {
case 10:
  fmt.Println("x == 10")
case 20:
  fmt.Println("x == 20")
case 30, 40:
  fmt.Println("x == 30 or 40")
default:
  fmt.Println("don't know what x is")
}
```

- In this form, a case statement is executed if any of the matches are equal to the value. The value and the matches must be the same type.
- Default executes if no match == value. default may be omitted.
- The first case to match executes. Any following cases do not.
- The case executes all statements inside the case.

SWITCH

- Another form simply adds an [init statement]:

```
switch [init statement]; [conditional] {
case [match]:
  [statement]
case [match], [match]:
  [statement]
  [statement]
default:
  [statement]
}
```

Example

```
switch x := y % 2; x {
case 0:
  fmt.Println("x == 0")
case 1:
  fmt.Println("x == 1")
}
```

- The [init statement] in the example is not very practical, it is just an example. This might be the output of a function or the combination of multiple variables in the real world.
- There is no default statement. If x was anything but 0 or 1 (it can't be in the example), nothing would execute and the code would continue.

SWITCH

- Another form uses each case statement as a conditional instead of a match:

```
switch {
case [conditional]:
  [statement]
case [conditional]:
  [statement]
default:
  [statement]
}
```

Example

```
switch {
case x < 10:
  fmt.Println("x < 10")
case x > 10:
  fmt.Println("x > 10")
}
```

- In this form, each conditional is matched against true/ false. If the case conditional == true, the case statements are executed.

EXERCISE

- Write an if/else statement that:
  - Prints “even” if an integer variable x is an even number
  - Print “odd” if it is not.
    - Hint: use the modulus % operator
- Write a switch statement that:
  - Prints “unix” if a string variable os is “linux”, “bsd”, “osx”
  - Print “microsoft os” if os is “windows10”
  - Prints “unknown os” if os is none of the above.
- Answer at: https://play.golang.org/p/dhgFm6P-3p

FUNCTIONS

ALL THE GOOD LANGUAGES HAVE THEM

FUNCTIONS

- Functions are defined using the func keyword:

```
func <function name>([var name] [var type], [var name] [var type], …) ([return value], [return value], …) {}
```

- A simple example of a function that adds two numbers together called add():

```
func add(x int, y int) int {
  return x + y
}
```

Example use of function add()

```
func main() {
  fmt.Println(add(2, 2))
}
```

- add() is defined as a function that takes in two integers, x and y. It returns an integer.
- Inside add(), we use the return keyword to return the results of adding x and y together.
- The function's code is enclosed in curly brackets {}

FUNCTIONS

- Functions can also save space by omitting the some of the types when multiple variable share the same type.
- Functions can return multiple values

```
func addMultiply(x, y int) (int, int) {
  return x+y, x*y
}
```

Example use of function addMutiply()

```
func main() {
  a, m := addMultiply(3, 3)
  fmt.Printf("3 + 3 is %d\n", a)
  fmt.Println("3 * 3 is ", m)
}
```

- x and y are both type int.
- We return two values, both are int. If you return multiple values, they must be in parenthesis (). This can be omitted for single value returns.

FUNCTIONS

- Functions can also have named returns.

```
func addMultiply(x, y int) (add, multiply int) {
  add = x+y
  multiply = x *y
  return
}
```

- Notice that in the function, we do not create x or y with := ? That is because they are already declared.
- Your return does not have to contain anything, because we will return the values in add and multiple.
- If you do not set a value for a named return, it returns the Zero Value. In this case, it would be 0. This is a common gotcha.

```
func addMultiply(x, y int) (add, multiply int) {
  return x+y, x*y
}
```

- This also works. In this case, add and multiply are there only to give additional information to the user.

EXERCISE

- Create a function that:
  - Is named divide.
  - Takes in two ints.
    - The first is the number to divide (dividend).
    - The second is the number to divide by (divisor).
  - Returns the result of the division.
  - Call the divide() function from main() and print the result.
- Answer at: https://play.golang.org/p/WW6Hop1EQn

EXERCISE

- Change divide() so that it:
  - Returns both the result of the division and the remainder.
  - Uses named returns.
    - Hint: use the modulus % operator
- Answer at: https://play.golang.org/p/-6QKd5pRyD

VS.

PUBLIC VS. PRIVATE

WHAT TO SHOW AND WHEN TO SHOW IT

PUBLIC AND PRIVATE

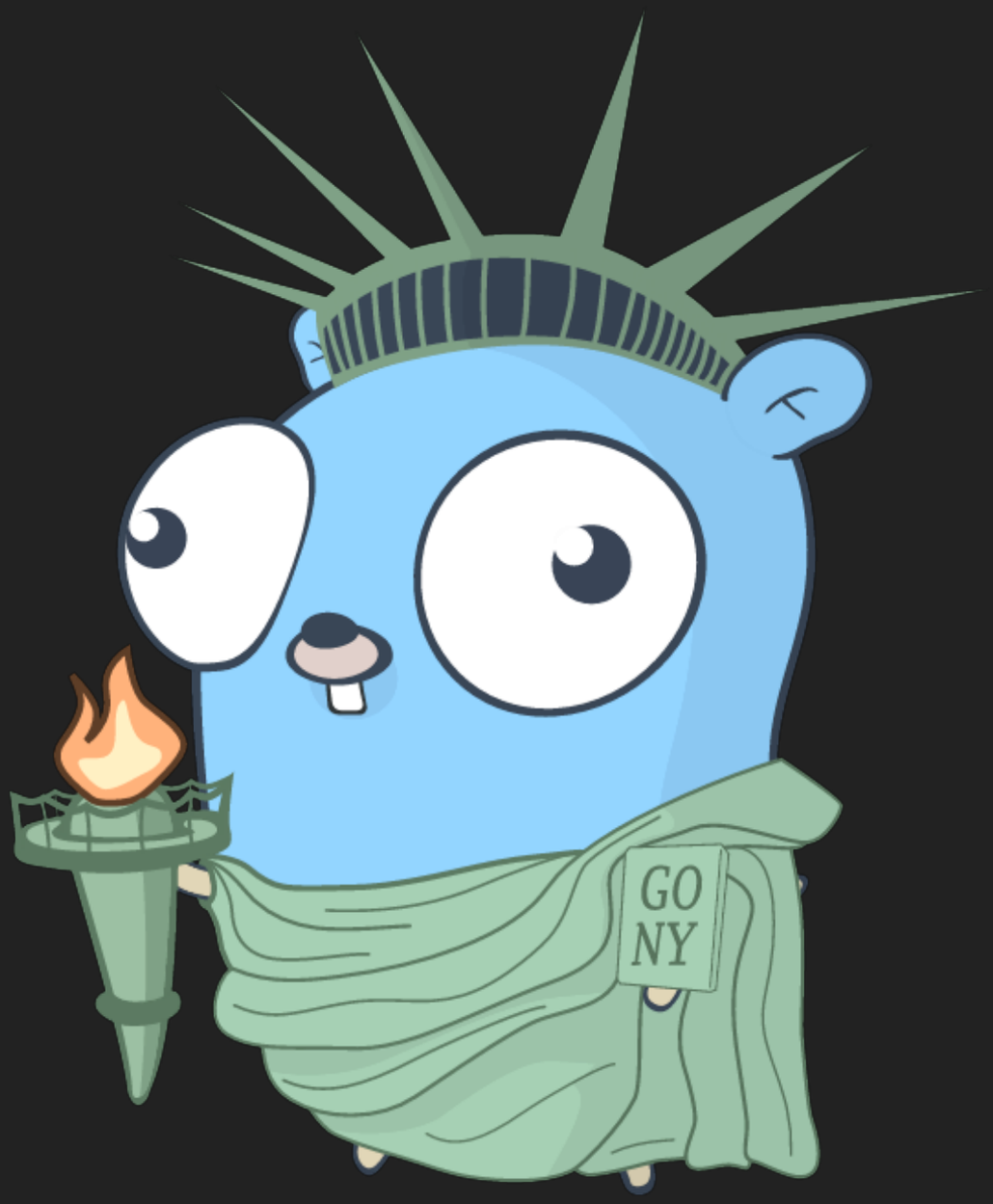
- Go provides both Public and private variables, functions, and methods.
- private variables, functions, custom types and methods may only be accessed inside a package.
- Public variables, functions , custom types and methods may be accessed by other packages.
- To be a Public variable, function or custom type, it must be at the root of the package (not inside a function or method).
- Declaring a Public or private variable/function/… is easy:
  - Public variables/functions/… starts with a CAPITAL LETTER.
  - private variables/functions/… start with a lowercase letter.

PUBLIC AND PRIVATE

- Example:

```go
package stuff

import "fmt"

func PrintHello() {
  fmt.Println("Hello")
}

func printWorld() {
  fmt.Println("World")
}

func PrintHelloWorld() {
  PrintHello()
  // printWorld is private, but accessible because
  // it is in the same package.
  printWorld()
}
```

```go
package main

import ".../stuff" // ... just means some path.

func main() {
  // This will work.
  stuff.PrintHello()

  // This will work.
  stuff.PrintHelloWorld()

  // Will get a compile error.
  stuff.printWorld()
}
```



VARIABLE SCOPING

EVERYTHING THAT HAS A BEGINNING, HAS AN ENDING – FAKE BUDDHA QUOTE

VARIABLE SCOPING

- Variable scope - the range in the code where a variable may be referenced.
- In Go, variables can be two types:
  - Package Global - they are defined outside any functions.
  - Package Local - they are defined inside a function.
- Global variables can be referred inside any function.
- If the Global is public, it can be referred to by other packages.

VARIABLE SCOPING

- Examples of global scope variables.

```go
package blah

var (
  // Multiplier can be accessed by outside packages by referencing
  // blah.Multiplier
  Multiplier = 3

  // divider can only be accessed within the package.
  divider = 2
)

func IncreaseByMultiplier(x int) int {
  return x * Multiplier
}

func DivideByTwo(x int) int {
  return x/divider
}
```

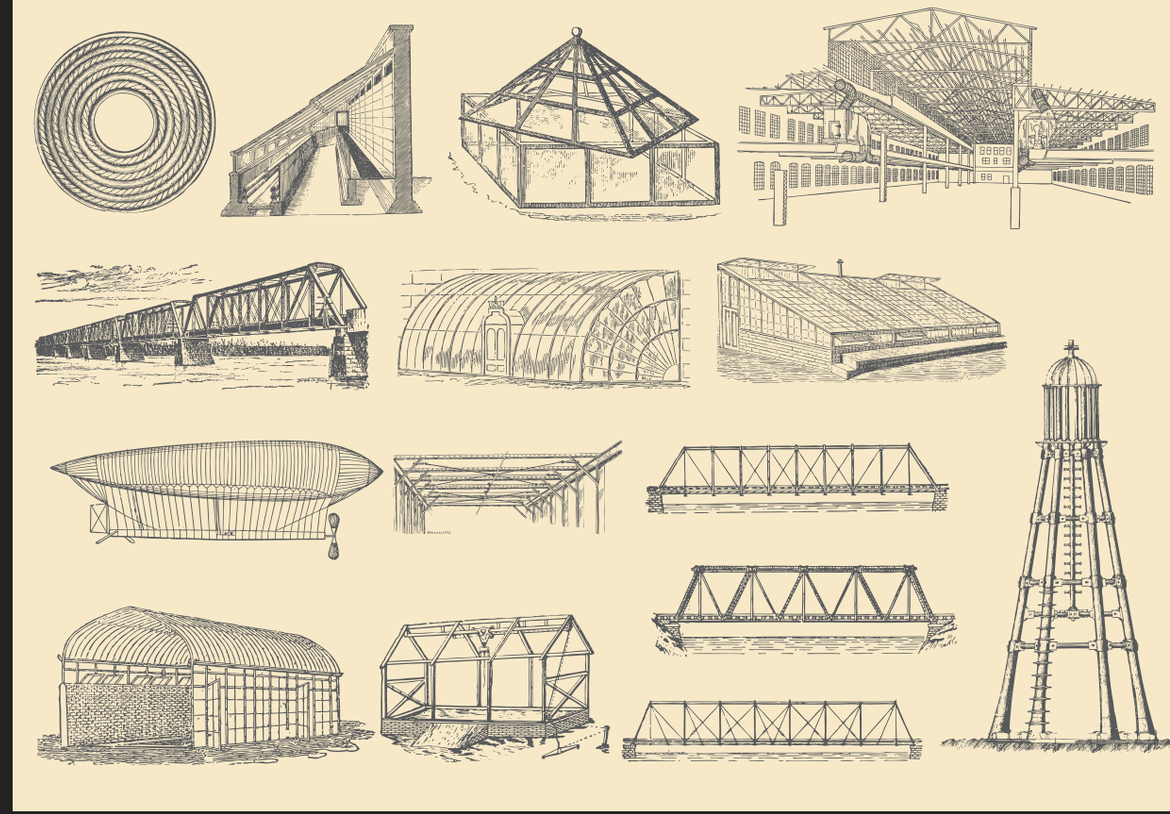
```go
package main

import ".../blah" // ... stands for a directory path.

func main() {
  blah.Multiplier = 10

  // blah.divider = 2 // Won't work, divider isn't public.

  fmt.Println(blah.IncreaseByMultiplier(4))
}
```

VARIABLE SCOPING

- Local variables have limited scope. They exist only between the closest braces { }, with one exception.
- The exception is if the variable is defined within an init statement of a for loop, if/else statement, or switch statement.
- If defined in an if init statement, the the starting brace { of the if to the final } of an else or if/else is the scope.

VARIABLE SCOPING

```go
func someFunc() {
  // str can be accessed by anything inside someFunc().
  // It cannot be accessed outside someFunc().
  str := "Hello World"
  fmt.Println(str)

  // i is accessible only inside the for loop.
  // It cannot be accessed outside the for loop.
  for i := 0; i < 10; i++ {
    fmt.Println(i)
  }
  // fmt.Println(i) - uncommenting this will be a compile error.

  // If you need for a loop variable to exist outside the loop, do this:
  var x int
  for x = 0; x < 10; x++ {
    fmt.Println(x)
  }
  // This works because x is declared outside the for loop.
  fmt.Println(x)

  // We create a variable z that is a random integer
  // using the standard library "math/rand".
  if z := rand.Int(); z == 0 {
    fmt.Printf("we randonly got 0 back")
  }else if z < math.MaxInt32 {
    // We can see z here because we are still within the entire if/else if/else.
    fmt.Printf("our random number %d fits in an int32", z)
  }else{
    // Same as above.
    fmt.Printf("our random number %d fits in an int64", z)
  }
  // fmt.Println(z) - uncommenting this will be a compile error.
}
```



STRUCTS

WHAT IS IN A NAME? THAT WHICH WE CALL A CLASS BY ANY OTHER NAME WILL SMELL AS SWEET – WILLIAM SHAKESPEARE

STRUCTS

- Go inherits the struct type from the C language.
- Structs provide groupings of named attributes.
- This is the closest language primitive to classes in other languages.
- Structs are normally used by creating customized structs using the type keyword.

STRUCTS

- An example of a custom struct that represents an employee record:

```go
// EmployeeRecord holds information about a company's employee.
type EmployeeRecord struct {
  // FirstName is the first name of the employee.
  FirstName string
  // Lastname is the last name of the employee.
  LastName string
  // ID is the employee's unique employee ID.
  ID int
}
```

- Creating an instance of the struct:

```go
rec := EmployeeRecord{
  FirstName: "John",
  LastName: "Doe",
  ID: 0,
}

fmt.Println("The employee's first name is: %s", rec.FirstName)
```

The . operator allows access to the struct's fields.

STRUCTS

- Structs can have methods attached to them, similar to classes of other languages.
- Methods are like functions with two key exceptions:
  - Methods can receive the struct without passing it as an argument.
  - Methods can only be called on an instance of a struct.

STRUCTS

- Let’s add a method that returns a string for printing out a record:

```go
// EmployeeRecord holds information about a company's employee.
type EmployeeRecord struct {
  // FirstName is the first name of the employee.
  FirstName string
  // Lastname is the last name of the employee.
  LastName string
  // ID is the employee's unique employee ID.
  ID int
}

func (e EmployeeRecord) String() string {
  // Sprintf is like Printf except that instead of writing to the screen,
  // it returns a string.
  return fmt.Sprintf("First: %s;Last: %s;ID: %d", e.FirstName, e.LastName, e.ID)
}
```

This provides access to the fields in Employee record by using the variable named e and attaches it to the struct.

We access the fields here via e.<field name>

STRUCTS

- Let’s use our method to print the record in our preferred form:

```
rec := EmployeeRecord{
  FirstName: "John",
  LastName: "Doe",
  ID: 0,
}

fmt.Println(rec.String())
```

- Will print: First: John;Last: Doe;ID: 0

EXERCISE

- We are going to simply recreate something similar to what we did in the previous slides. Note the differences.
- Create a struct called Record
  - Create field First of type string
  - Create field Last of type string
  - Create field ID of type int
- Add method String() onto Record
  - It should return a string that represents the Record in CSV:
    - <ID>,<First>,<Last>
- Answer at: https://play.golang.org/p/bvPSxtwVdk

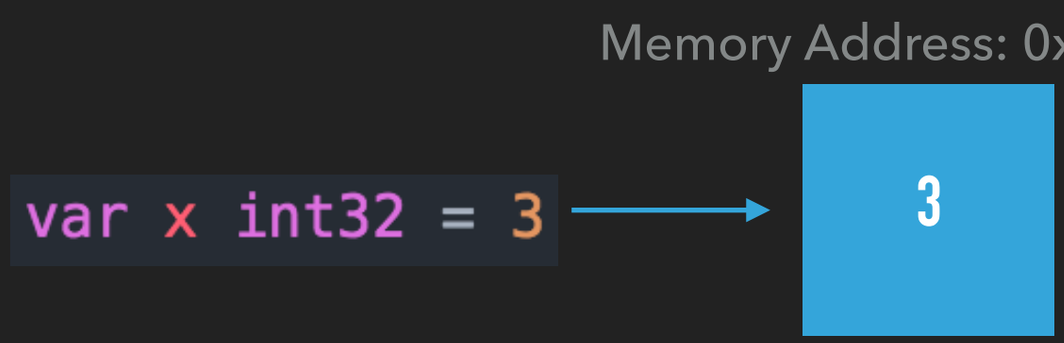
SAVE THIS EXERCISE FOR USE LATER

WHAT'S THE POINTER

POINTER HUMOR, ALWAYS A BIG HIT AT THE PARTIES

UNDERSTANDING POINTERS

- To understand pointers, its important to understand what happens when you create a variable, in simple terms.

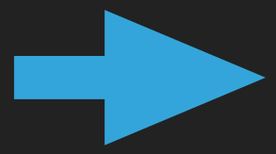


- When a variable is created, such as the int x represents, memory must be allocated to store that value.
- In the instance above, a place in memory is created, addressed with a fictional address of 0x345693.
- That memory address must be 32 bits in size to store the 32 bit number.

UNDERSTANDING POINTERS

```go
func changeInt32(x int32) {
  x = 10
  fmt.Printf("Inside changeInt32: %d\n", x)
}

func main() {
  var x int32 = 100
  changeInt32(x)
  fmt.Printf("After changeInt32: %d\n", x)
}
```

Outputs



Inside changeInt32: 10

After changeInt32: 100

- Not what you were expecting? Why did it not change?
- The value didn’t change because values are copied when going into a function. It is ALWAYS copied.

UNDERSTANDING POINTERS

- It is also important to understand how passing variables to functions work.

1. `var x int32 = 100`

Memory Address: 0x345693

Creates new variable in memory

2. `changeInt32(x)`

Memory Address: 0x345693

3. `func changeInt32(x int32) {`

Memory Address: 0x987345 (new memory address)

Copies value into new variable

4. `x = 10`

Memory Address: 0x987345

Value Changed

5. `}` Function ends

Memory Address: 0x987345

Memory reclaimed

UNDERSTANDING POINTERS

- Pointers are types whose value is a memory address.
- This is similar to an int whose value is an integer.
- By using the Pointer's memory address, you can access the value that is stored at the address.
- By passing pointers to variables instead of the value of a variable, you can change values inside a function.

UNDERSTANDING POINTERS

- A pointer type can be created several ways:
  - var intptr *int
    - Creates a pointer to a int. Because it doesn't point at anything, it gets the Zero Value, which is nil.
  - var intptr = new(int) or intptr := new(int)
    - new creates an address in memory to store an int and then returns a pointer which points to that address. The value in the memory address is the Zero Value of the type, which in this case is 0.
  - intptr := &x
    - x in this case would hold an int.
    - & indicates to return the address where variable x is stored.

UNDERSTANDING POINTERS

- You can access a value stored by a pointer by dereferencing the pointer.
- Dereferencing is done by putting a * in front of the pointer name.

```
intptr := new(int)

// This will print 0, the Zero Value stored at the place in memory
// intptr points to.
fmt.Println(*intptr)

// This changes the value stored in intptr to 25.
*intptr = 25

// This will print 25.
fmt.Println(*intptr)

// This will print the memory address that intptr stores.
fmt.Println(intptr)

// intptr  = 10 - Uncommenting this will prevent this from compiling.
```

- Try it at: https://play.golang.org/p/4pOyueVEWD

UNDERSTANDING POINTERS

- Let's try the changeInt32 example again, using pointers.

```
func changeInt32(x *int32) {
  *x = 10
  fmt.Printf("Inside changeInt32: %d\n", *x)
}

func main() {
  var x int32 = 100
  changeInt32(&x)
  fmt.Printf("After changeInt32: %d\n", x)
}
```

- Try it at: https://play.golang.org/p/9k7Kp5BJBm

UNDERSTANDING POINTERS

- BUT WAIT! You said the you always copy values when you are going into a function. So why do pointers let us change the value?

- Answer: We are still copying the values, but the value has changed from being an int to a memory address.
- When we dereference the copy of the memory address, it is still the same address.

UNDERSTANDING POINTERS

1. `var x int32 = 100`

Memory Address: 0x345693

100

Creates new variable in memory

2. `changeInt32(&x)`

Memory Address: 0x345693

100

3. `func changeInt32(x *int32) {`

Memory Address: 0x987345 (new memory address)

0X345693

Copies value into new variable. Value is the memory address .

This is the memory address of x in the main() function

4. `*x = 10`

Memory Address: 0x345693

10

Value Changed

5. `}` Function ends

Memory Address: 0x987345

0X3[illegible]693

Memory reclaimed

EXERCISE

- Create a function called changeStr()
  - Takes in a pointer to a string
  - Changes the string to “Hello World”
- In main():
  - Create a string variable that stores “Howdy Partner”
  - Print the string variable.
  - Call changeStr() passing the string pointer.
  - Print the string variable.
- Answer at: https://play.golang.org/p/b1gueGy6uI

UNDERSTANDING POINTERS

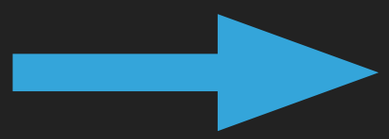
- A note on reference types
  - Reference type act as if they have a built in pointer.
  - If you pass a reference type to a function and change it in a function, you change it outside too.
- Reference types are maps, slices and channels.

UNDERSTANDING POINTERS

- A slice gotcha:
  - Changing a slice in a function indeed changes the slice outside the function.
  - However, altering the length of the slice does not change the length outside. To do that you must either return the slice or pass a pointer to the slice.

```
func changeSlice(s []string) {
  s[0] = "blueberry"
  s = append(s, "watermelon")
}

func main() {
  s := []string{"apples"}
  changeSlice(s)
  fmt.Printf("%#v\n", s)
}
```

Outputs



[]string{"blueberry"}

- Try it at: https://play.golang.org/p/1NR9sZVl7y

UNDERSTANDING POINTERS

- Solutions to the gotcha:

```
func changeSlice(s *[]string) {
  *s = append(*s, "watermelon")
}

func returnSlice(s []string) []string {
  return append(s, "bananas")
}

func main() {
  s := []string{"apples"}

  changeSlice(&s)
  fmt.Printf("%#v\n", s)

  s = returnSlice(s)
  fmt.Printf("%#v\n", s)
}
```

Outputs

[]string{“apples”, ”watermelon"}

[]string{“apples”, ”watermelon”, "bananas"}

- Try it at: https://play.golang.org/p/-Rlm4M9KVdJ

UNDERSTANDING POINTERS

- Struct gotcha's to look out for:
  - Many people forget that a struct is not a reference type. You often need to use a pointer to a struct.
  - Methods need to use pointers to change fields, otherwise they are changing copies of the struct, not the struct.

```
type someStruct struct{
  field string
}
func (s someStruct) change() {
  s.field = "hello"
}

func main() {
  s := someStruct{field: "world"}
  s.change()
  fmt.Println(s.field)
}
```

- Try this at: https://play.golang.org/p/crTa2KrgZ0

UNDERSTANDING POINTERS

- Gotcha's fix:

```
type someStruct struct{
  field string
}
func (s *someStruct) change() {
  s.field = "hello"
}

func main() {
  s := &someStruct{field: "world"}
  s.change()
  fmt.Println(s.field)
}
```

Outputs

hello

- Try this at: https://play.golang.org/p/36hivvD3Tz

UNDERSTANDING POINTERS

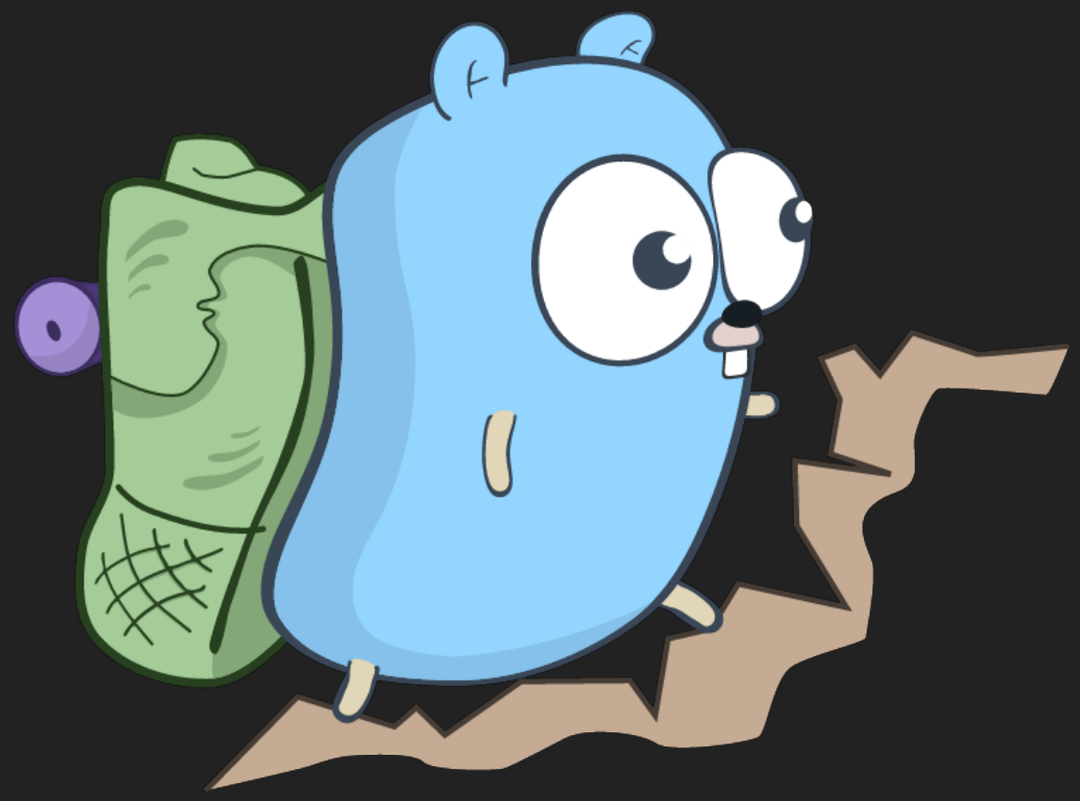
- Final Notes on Pointers
  - A pointer to a pointer is as deep as you should go. This isn't Inception.
  - Don't overuse pointers. Use them where copying data is expensive. While we used them on int and string in our examples, generally you do this on structs and not basic types.
  - Copying data between functions (which happens on the stack) is usually much faster than allocating pointers and then copying them between functions (which requires heap allocation).
  - The default nil value in references and pointers is useful for detecting empty values.

EXERCISE

- Exercise concept:
  - We want to create a digital file cabinet storing employee records.
  - We want to create a record for an employee.
  - We want the record to have a unique ID.
  - We want to store the record in the file cabinet.
  - We want to be able to print all records in the cabinet in the order they were added.

EXERCISE

- Load the “Record” exercise you were asked to save.
- Create a new struct call FileCabinet.
  - Add a field called Files of type slice of Record.
  - Add a field called nextID of type int.
  - Create a method called AddRecord on FileCabinet.
    - Should have arguments named first and last which are of type string.
    - Method should create a new Record with an ID that is equal to nextID.
    - Method should increment nextID by 1.
    - Method should store the new Record in FileCabinet.Files
- In main():
  - Create a variable called fc of type *FileCabinet.
  - Call fc.AddRecord() 3 times with different names.
  - Use a for loop with range to print out all the entries in fc.Files
- Answer is at: https://play.golang.org/p/Hdy4Mi3eyt



DETECTING KEYS IN MAPS

LOST VARIABLES ARE NEVER FOUND AGAIN –BENJAMIN FRANKLIN

FINDING KEYS IN MAPS

- Map lookups have two different syntaxes:
  - Retrieve a value at key:

```
<value> := mapVar[<key>]
```

  - Retrieve a value at key, determine if key exists:

```
<value>, <found bool> := mapVar[<key>]
```

- Example of key lookup:

```go
m := map[string]int{"apples": 1}

// Does "apples" exist as a key in "m".  If so,
// return the value stored and boolean true.
if v, ok := m["apples"]; ok {
  fmt.Printf("Found key %q with value %d", "apples", v)
}else{
  fmt.Printf ("Key %q not found", "apples")
}
```

EXERCISE

- Create a map called authorToBooks
  - Keys are strings
  - Values are a slice of strings
  - Use a composite literal to add the following:
    - “joseph heller”: []string{“catch 22”, “something happened”}
    - “nate silver”: []string{“the signal and the noise”}
  - In main():
    - Create a slice of authors who are and are not in the map.
    - Loop through the slice looking to see if the author exists. If so, print their books one at a time in a for loop.
    - If the author is not in the map, print that you cannot find the author.
- Answer at: https://play.golang.org/p/lc5u5pHxbx

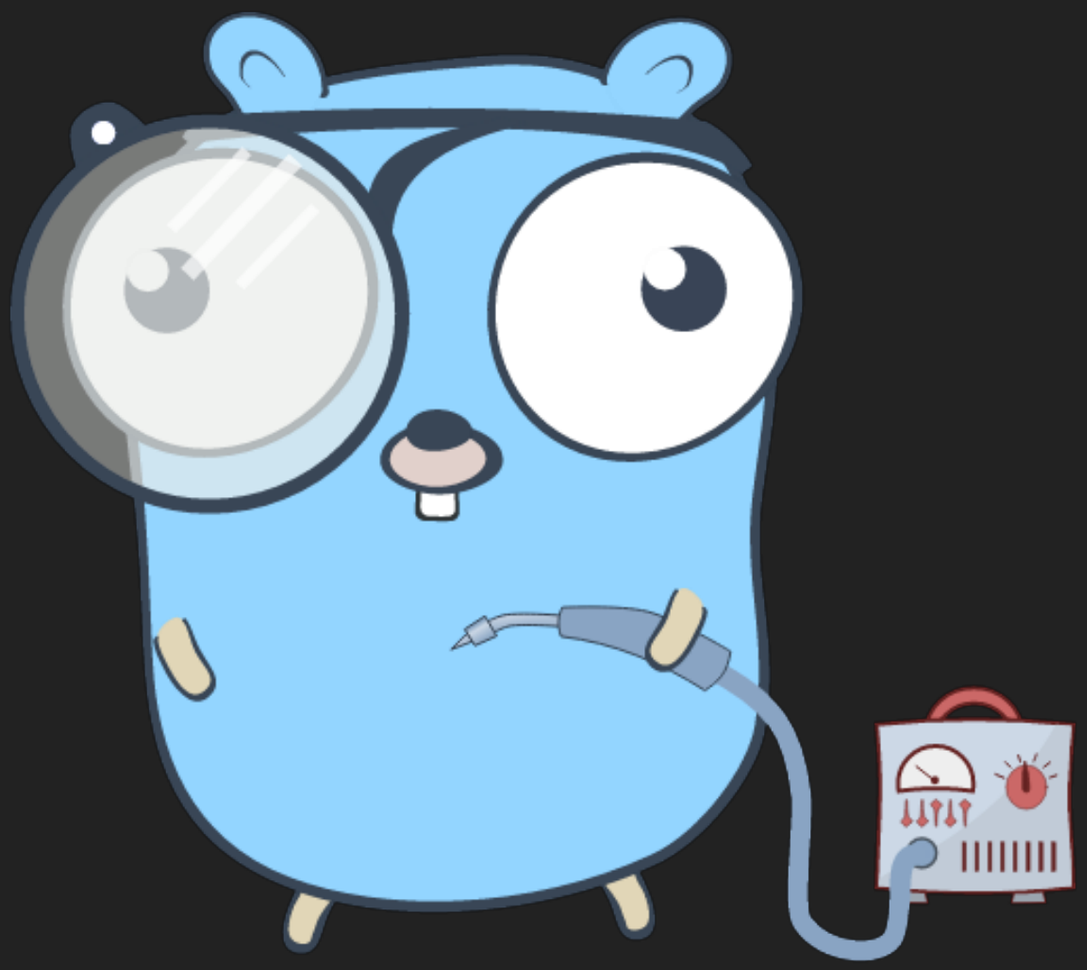
FINDING KEYS IN MAPS

- When using a map to only detect if a key exists, not to retrieve a value, we can use a map with value type of bool.
- This makes detection quicker:

```
// foodsIlike is a map of foods like.  I'm very selective.
var foodsILike = map[string]bool{
  "bbq": true,
  "milkshakes": true,
}

// willEat determines if I will eat a meal that contains various foods.
// I'm picky, so if I don't like one food, I don't eat the meal.
func willEat(meal []string) bool {
  for _, f := range meal {
    if !foodILike[f]{
      return false
    }
  }
  return true
}
```

EXERCISE

- Create a map called goodMovies
  - Keys are strings
  - Values are bools
  - Use a composite literal to add the following:
    - “princess bride”: true
    - “blade runner”: true
    - “memento”: true
    - “i’m gonna get you sucker”: true
  - In main():
    - Loop through a slice containing a good movie and “prometheus”.
    - Print if its a good movie or not.
- Answer at: https://play.golang.org/p/GiXj2dizdz



VARIADIC FUNCTIONS

ALL YOU NEED IN LIFE IS VARIADIC FUNCTIONS AND CONFIDENCE, AND SUCCESS IS SURE – MARK TWAIN

VARIADIC FUNCTIONS

- Variadic functions are simply functions that can take a variable number of arguments.
- In Go, you can specify a variable number of arguments using the ... operator.
- ...<type> can only be the last variable in the function call.
- Inside the function call, the variable will be a []<type>.

```
func Sum(nums ...int) int {
  s := 0
  for _, n := range nums {
    s +=n
  }
  return s
}
```

VARIADIC FUNCTIONS

- Why not just use []int in the previous example?
- Simply a nicety, you can use []int:

```
func Sum(nums []int) int {
  s := 0
  for _, n := range nums {
    s +=n
  }
  return s
}
```

- But doesn't this look nicer?

```
x := Sum(1, 5, 7, 9)
```

- Than this?

```
x := Sum([]int{1, 5, 7, 9})
```

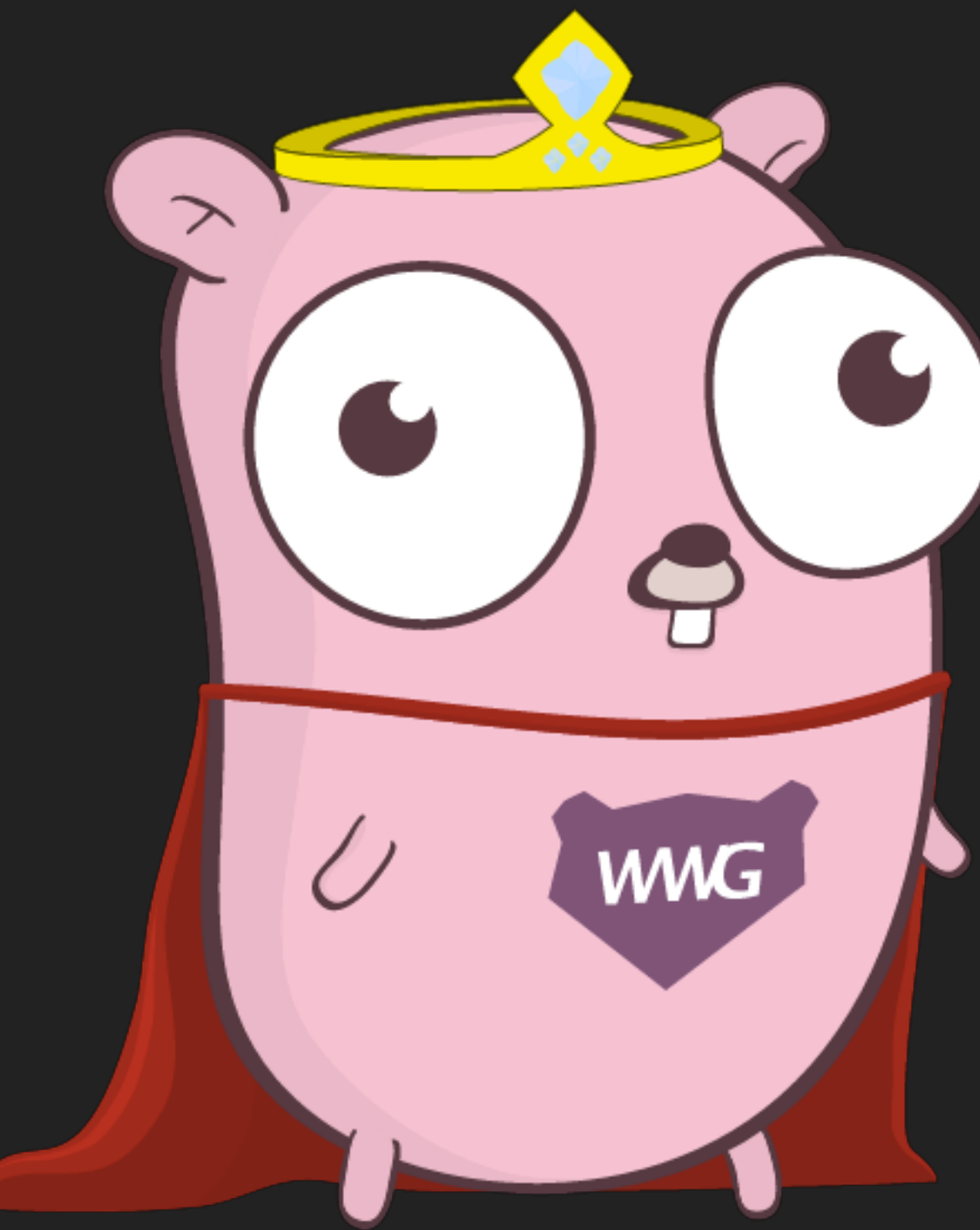
EXERCISE

- Create a function called PrintStrs.
  - Has an argument called strs that is a variable number of string arguments.
    - It prints each argument on its own line.
- In main():
  - Use PrintStrs() to print out a list of strings.
- Answer at: https://play.golang.org/p/pMeaXsGmTk

VARIADIC FUNCTIONS

- The ... operator can also be used to unpack a []type into a function's variable arguments.
- For example, append() takes variable arguments of a type, but doesn't take a slice of a type.
- By putting the ... after the a slice type, it unpacks the slice into individual variable arguments.
- Example:

```
fruits := []string{"mango", "pears"}
californiaFruits := []string{"oranges", "apples"}

// Lets append californiaFruits onto fruits.
fruits = append(fruits, californiaFruits...)

// fruits = append(fruits, californiaFruits) - will not work
```



ERROR HANDLING

BAD CODE BREAKS SOFTWARE AND AFTERWARD, SOME CODE IS STRONG AT THE BROKEN PLACES
–ERNEST HEMINGWAY

ERROR HANDLING

- Go does not attempt to handle error conditions with exceptions that many other languages use.
- Instead, Go couples the ability to have multiple return variables and an error type called error.
- The error type has a Zero Value of nil, which can be checked with a simple if statement.
- Errors are generally created in two ways:
  - For simple text errors with no variable substitution:
    - import “errors”
    - errors.New(“my error message”)
  - For errors with variable substitution:
    - import “fmt”
    - fmt.Errorf(“i didn’t like input: %s”, str)

ERROR HANDLING

- A common type of error to deal with is the inability to open a file.
- This example tries to print a file's content using a standard library called ioutil to read a file.
- If it can't, we return an error. The caller can then determine how to deal with that error.

```
// PrintFile prints the content of file fn to the screen.
func PrintFile(fn string) error {
  content, err := ioutil.ReadFile(fn)
  if err != nil {
    // We could just return the error, but this allows us to add more
    // context to the error returned by ioutil.ReadFile().
    return fmt.Errorf("could not read file %s: %s", fn, err)
  }

  fmt.Println(string(content))

  return nil
}

func main() {
  files := []string{"exists", "does not exist"}

  for _, fn := range files {
    if err := PrintFile(fn); err != nil {
      fmt.Println("Error: %s", err)
    }
  }
}
```

EXERCISE

- Create a function called Divide()
  - Takes in two arguments:
    - Dividend of type int
    - Divisor of type int
    - Returns an int and an error
    - Detects if the Divisor is 0. If so, it returns the int Zero Value and an error stating you cannot divide by 0.
- In main():
  - Call Divide() for a number divided by a positive number
  - Call Divide() for a number divided by 0.
  - Print each result or error.
- Answer at: https://play.golang.org/p/7gn-d1Kai7

ANONYMOUS FUNCTIONS

THE PROBLEM WITH LOSING YOUR ANONYMOUS FUNCTIONS IS THAT YOU CAN NEVER GO BACK

–MARLA MAPLES

ANONYMOUS FUNCTIONS

- Anonymous functions are simply functions that are defined without a name.
- You can define anonymous functions and assign them to a variable (variables can be a function type).
- You can define an anonymous function inside another function.
- Anonymous functions are useful for features such as defer and goroutines, which we will use later.
- Example:

```
func helloWorld() {
  func(str string){
    fmt.Println(str)
  }("hello world")  // Notice the ("hello world") here?  This is where we call the function.
}
```

ANONYMOUS FUNCTIONS

- Assign to a variable example:

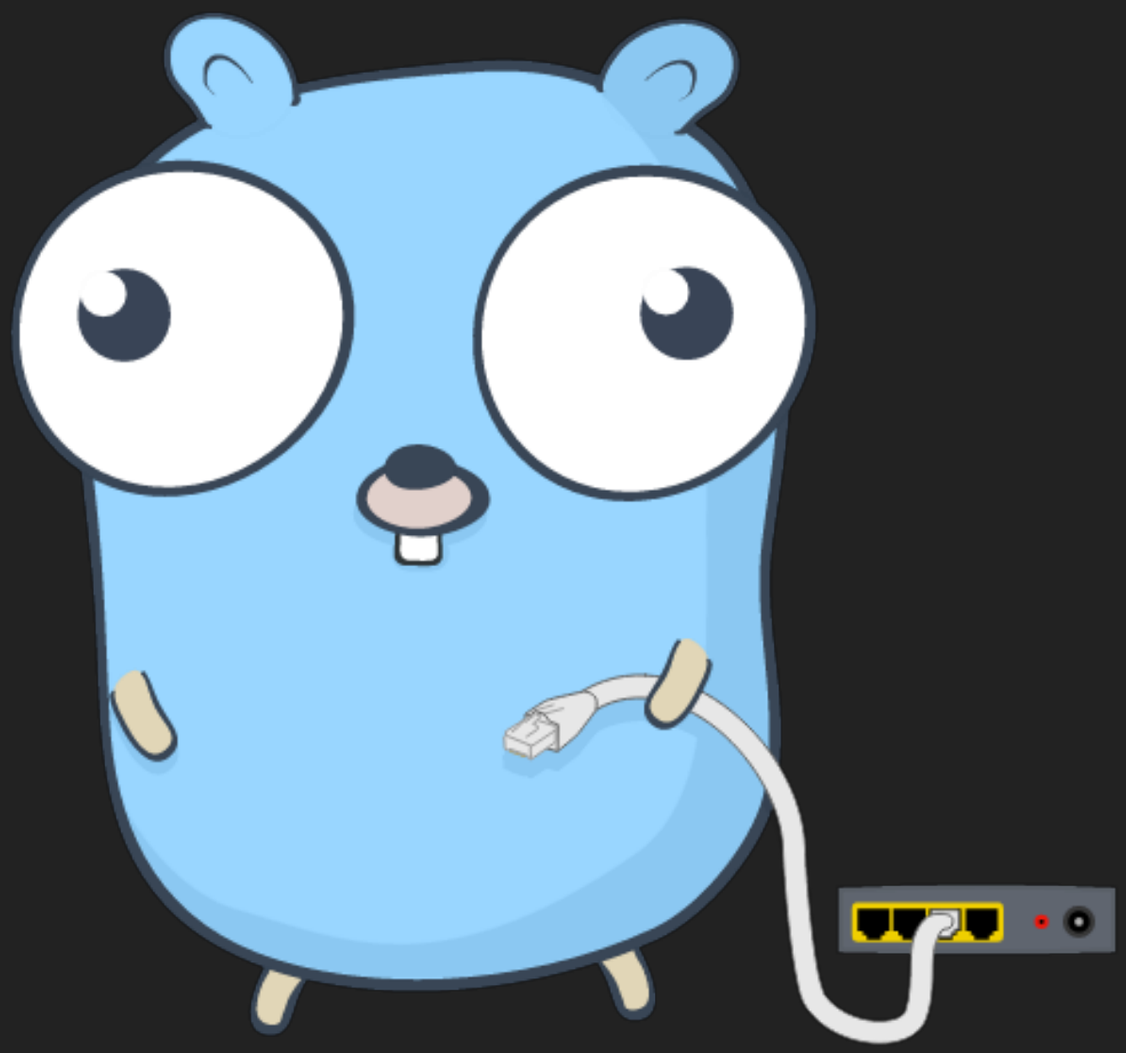
```
printer := func(str string) {
  fmt.Println(str)
}

printer("I don't think the quotes in the class are correct")
```

- Example with a return value:

```
var addition = func(x, y int) int{
  return x + y
}

z := addition(2, 2)
fmt.Println(z)
```

EXERCISE

- Create an anonymous function inside main that:
  - Takes in variadic arguments of type string.
  - Returns a string that is the concatenation of the arguments with a space in-between them.
  - Call the anonymous function with strings: “cat”, “dog”, “bear”.
  - Print the return value.
- Answer at: https://play.golang.org/p/mrCzIY0nrG



DEFER/PANIC/ RECOVER

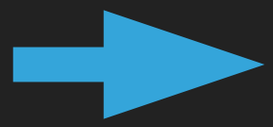
IF MY CODE PANICS,
EVERYONE ELSE'S PANICS.
–KOBE BRYANT

DEFER

- The keyword defer, followed by a function call will delay the call until the end of the containing function call.
- If there is more than one defer, the last defer statement goes first.

```
func printing() {
  defer fmt.Println("exiting")
  defer fmt.Println("I must be going")

  fmt.Println("Hello,")
}
```

Outputs



Hello,
I must be going
exiting

- Try it out at: https://play.golang.org/p/DCyvcVxdFo

DEFER

- Defer is useful to have a statement called once instead of at each exit point from the function.
- This is often used to unlock mutexes or close files.
- Here's an example using defer and without defer for closing a file.

```go
// filePrinter prints a file to the screen if it doesn't
// contain TOP SECRET in the file.  This is an example,
// its is not the most efficient way to do this.
func filePrinter(filePath string) error {
        f, err := os.Open(filePath)
        if err != nil {
                return err
        }
        defer f.Close()

        r := bufio.NewReader(f)
        output := ""
        for {
                out, err := r.ReadString('\n')
                if strings.Contains(out, "TOP SECRET") {
                        return fmt.Errorf("Top Secret file"))
                }
                output += out
                if err != nil {
                        break
                }
        }
        fmt.Println(output)
        return nil
}
```

```go
func filePrinter(filePath string) error {
        f, err := os.Open(filePath)
        if err != nil {
                return err
        }

        r := bufio.NewReader(f)
        output := ""
        for {
                out, err := r.ReadString('\n')
                if strings.Contains(out, "TOP SECRET") {
                        f.Close()  // Now I have to close it here.
                        return fmt.Errorf("Top Secret file"))
                }
                output += out
                if err != nil {
                        break
                }
        }
        fmt.Println(output)
        f.Close()  // And I have to here as well.
        return nil
}
```

EXERCISE

- Write a function called Sum that prints a sum of all numbers 1 to 100.
- The function will also print to the screen how long the function took to execute.
- To make sure the time exceeds 1 second, we want to sleep execution for 1 second.
- To do this, inside the function:
  - Record the start time of the function call to a variable called start using time.Now().
  - Uses defer to print out the total runtime of the function, using time.Now().Sub(start)
  - Sums the numbers 1 to 100 via a loop
  - Call time.Sleep(1 * time.Second) to pause execution for 1 second.
  - Prints the sum.
- The way you will try to make it work: https://play.golang.org/p/oBJtW1I_RnV
- Why you have a gotcha: https://play.golang.org/p/AStiy0SHV8V
- Answer at: https://play.golang.org/p/9EQNhayePr0

PANIC

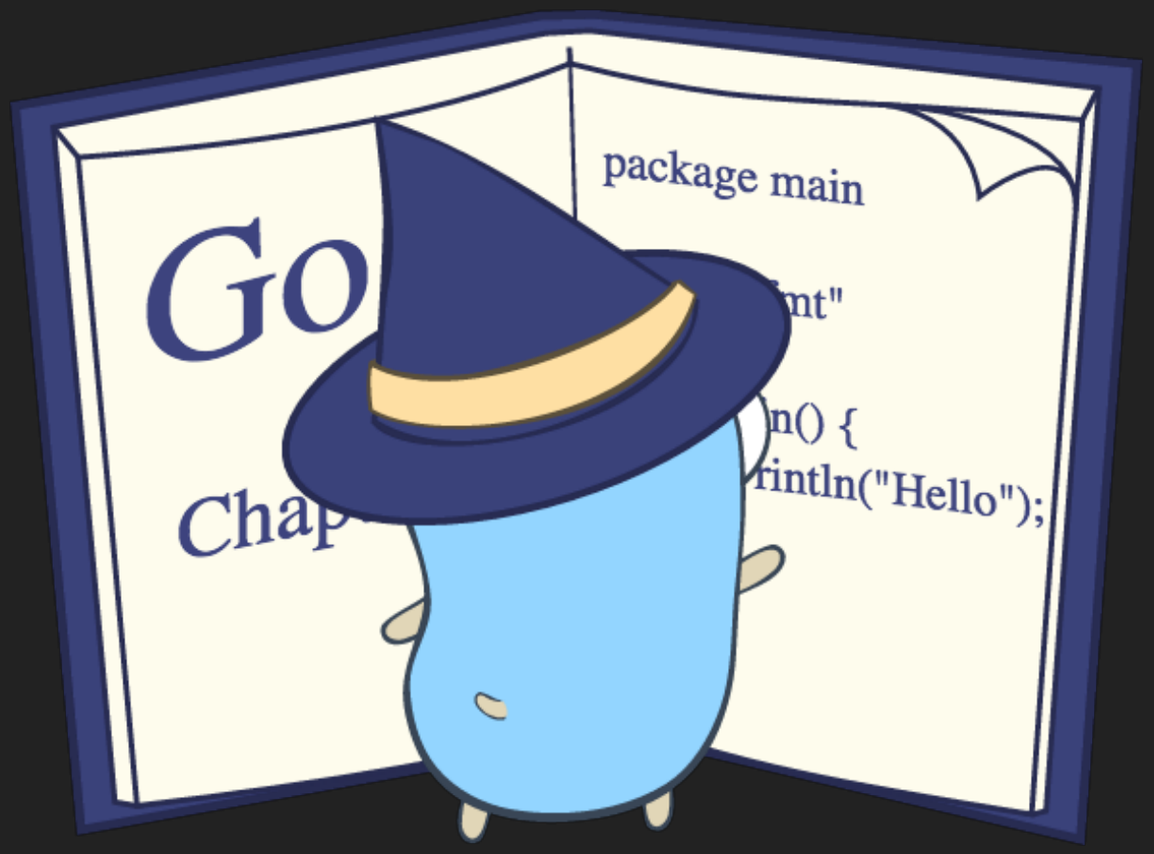
- panic simply causes your program to crash with a stack trace.
- Use only if the error is unrecoverable.
- Some general rules are:
  - Do this only on server side apps. Users of client applications have a bad experience when receiving stack traces.
  - Do this only in package main. Do not do this in other packages.

```
func main() {
  if !secureConnection() {
    panic("Anyone could be listening!")
  }
}
```

RECOVER

- The recover function can be used to recover from a panic in the stack.
- In most circumstances, if your doing recover, something is wrong.
- recover is paired with a defer, here's an example:

```
func main() {
  defer func() {
    if r := recover(); r != nil {
      fmt.Printf("Recovered from a panic, panic was: %q\n", r)
    }
  }()
  panic("hello")
}
```



INTERFACES

INTERFACES? WELCOME TO THE JUNGLE!
– AXL ROSE

INTERFACES

- An interface is a type, just like an int, string, etc…
- An interface requires that data stored in a variable have the following characteristics:
  - Must have the same methods as defined on the interface
  - Must have the same arguments for each method
  - Must have the same return values for each method
- Example:

```
var sample interface{Add(x, y int) int}
```

- This creates a variable, sample, of type interface{Add(x, y int) int}
- Only data that has a method called Add which takes two int arguments and returns an int can be stored here.

INTERFACES

```
var sample interface{Add(x, y int) int}

type notRight struct{}

func (n notRight)Hello() {
  fmt.Println("hello")
}

// The following line won't work as notRight does not have the right metho
// sample = notRight{}

type math struct {}

func (m math) Add(x, y int) int {
  return x+y
}

func (m math) Subtract(x, y int) int {
  return x-y
}

// This will work, because it does have the right method.
sample = math{}

// I can call this, because it is defined on the interface.
fmt.Println(sample.Add(3, 2))

// This will not work, because the interface does not define this method.
// fmt.Println(sample.Subtract(3, 2))
```

INTERFACES

- It is more common to have a custom interface type than to define it inline, as we did in the previous slide.
- An interface with no value assigned has a Zero Value of nil.

```
type Adder interface {
  Add(x, y int) int
}

var sample Adder
```

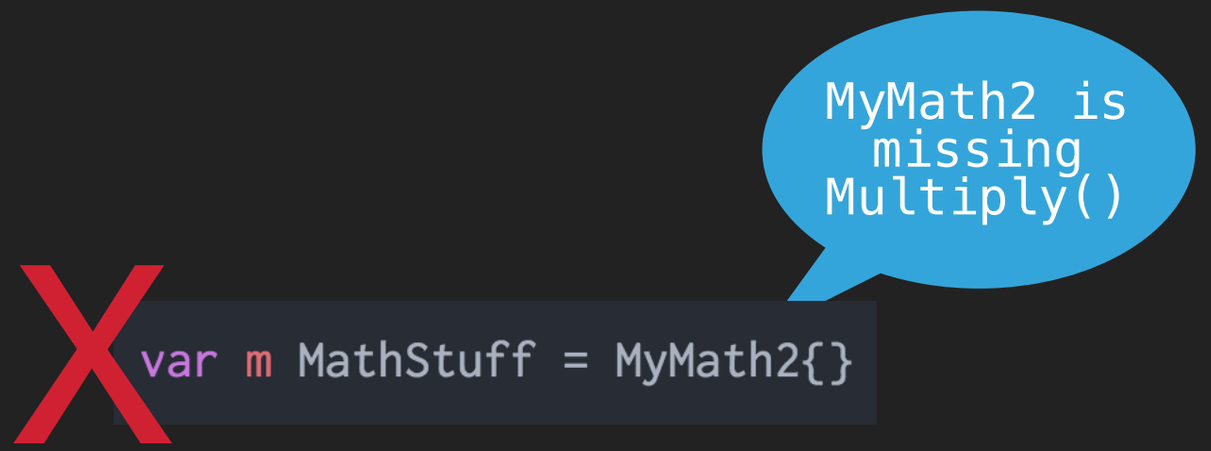
INTERFACES

```
type MathStuff interface {
  Add(x, y int) int
  Multiply(x, y int) int
}
```

```
type MyMath1 struct {}

func (m MyMath1) Add(x, y int) int {
  return x+y
}

func (m MyMath1) Multiply(x, y int) int {
  return x * y
}
```

```
var m MathStuff = MyMath1{}
```

```
type MyMath2 struct {}

func (m MyMath2) Add(x, y int) int {
  return x+y
}
```



INTERFACES

- So, why would you want an interface?
  - Interfaces can provide a simple contract that can be satisfied by multiple implementations.
    - File systems are a good example. Functions often want to access a file system and perform operations. You don't want to write the same function for each file system type. By providing an interface for file systems, you can implement support for the local file system, remote file systems (SFTP), specialized file systems (Hadoop HDFS), etc. Your function simply manipulates an interface representing a file system and becomes agnostic to what file system it is.
  - Abstracted storage is another. Often it is required to read and write records to some type of storage. Interfaces can often be useful to abstract these into a storage interface with different implementations. Customers can then store data in MySQL, in memory, or in various disk storage schemes. Your software never changes, you just plug in the new implementation.
  - Tests are another example. You may not want a test to make an expensive call or talk to an external system. By using an interface, you can use a fake implementation for tests and use the real implementation when in production.

INTERFACES

- Interesting note:
  - The error type is simply an interface.
  - You can satisfy that type with your own custom type.

```
// This is Go's built in error type.
type error interface {
  Error() string
}
```

```
type CustomError int

func (c CustomError) Error() string {
  return fmt.Sprintf("had a CustomError with error code %d", c)
}

func blah() error {
  return CustomError(1)
}
```

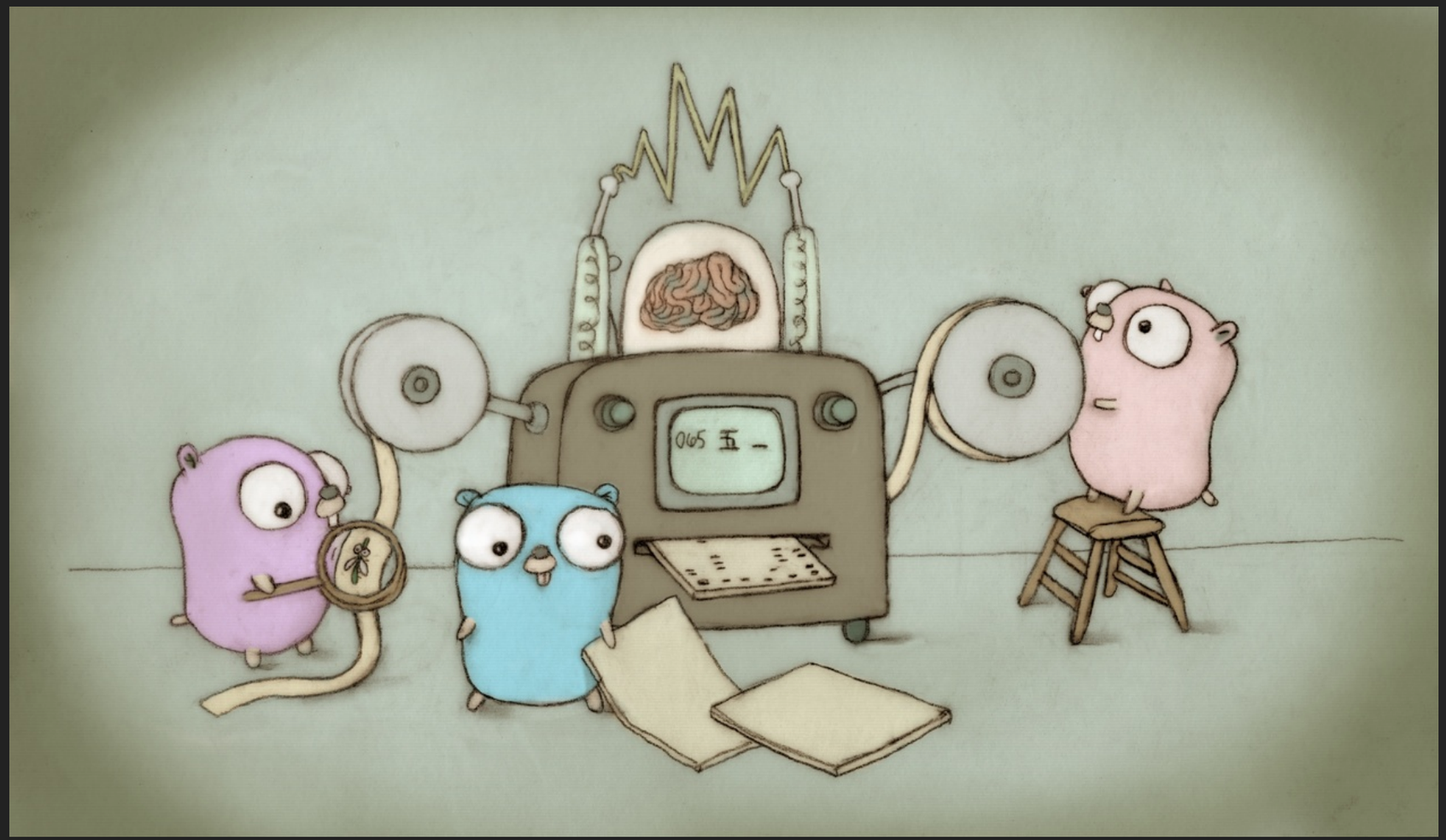
- The custom type above is built off the int type.
- Yes, a custom int can have a method! Its not just for the struct type.
- This one returns an error code and can store that error code for other uses.

EXERCISE

- Create an interface type called FileSystem
  - Has method Read(f string) ([]byte, error)
  - Has method Write(f string, b []byte) error
- Create a struct called inmemory
  - Has attribute map[string][]byte
  - Implement FileSystem reading and writing from map.
- Create a function called WriteReadme(fs Filesystem, pathStr string) error
  - This should write a README file to path/README
  - Can contain anything you want. You can do []byte(“README”) to convert a string to []byte.
  - Use the “path/filepath” package to join pathStr and “README”.
- In main()
  - Create a var called fs of type FileSystem
  - Call WriteReadme(fs, “/some/path/”)
  - Print out fs.Read(“/some/path/README”)
- Answer at: https://play.golang.org/p/r-fQulWHD_b

EXERCISE NOTES

- In general, you would not create your own FileSystem interface. This example is to make the exercise simple.
- The io package contains interfaces such as Reader, Writer, ReadWriter, … that are normally implemented for file systems.
- These filesystems might be local disk (accessed via os.OpenFile() or os.Open()), or HTTP requests from HTTP clients. Read/Write streams for file systems are almost always implemented using interfaces in the io package.
- If you want to simply open a file and read it into memory (which is great when your files are small), use the ioutil package.



GO ROUTINES

WAKE ME UP BEFORE YOU GO GO – WHAM!

GOROUTINES

- A goroutine is Go's method of starting a concurrent function
- A goroutine is similar to the idea of a thread, but:
  - Much lighter weight. You can create millions of goroutines on a laptop.
  - Goroutines run on top of threads, scheduled by the runtime, not the OS.
    - If you come from a C/C++ background, you don't need to be as judicious with goroutines.
- Creating a goroutine is as simple as:
  - go <function name>()

GOROUTINES

```go
func main() {
  for i := 0; i < 10; i++ {
    go fmt.Println("hello world", i)
  }

  // We haven't talked about select yet.  Here it is used to keep the program
  // from ending.  An empty select blocks forever.  Without this, we might
  // not see anything print, because then main() function might end before
  // any of the goroutines are able to print.
  // If you try this, everything will print, but the program will crash.
  // We will talk about better ways to handle this later.
  select{}
}
```

- This simply spins off 10 goroutines that will print “hello #”, where # is 0-9 in random order.
- When you use a goroutine, you no longer have control of sequencing, which is why 0-9 will print in random order.

SYNCHRONIZATION

- Synchronization is the process of preventing read and write access to a variable in two goroutines at the same time.
  - So, given a variable x:
    - Any number of goroutines can read the data in x
    - But if one of the goroutines must write to x, then you must use some form of synchronization.
    - It is undefined what will be in x if you do not use a synchronization method.
    - When two goroutines try to read and write to the same variable, this is called a data race. Go has a data race detector not covered here.
- To prevent data races, Go has channels and Mutexes.

CHANNELS

Channel

A synchronization primitive that allows sending data from senders to receivers. The amount that the Channel can hold is called the buffer.

Input

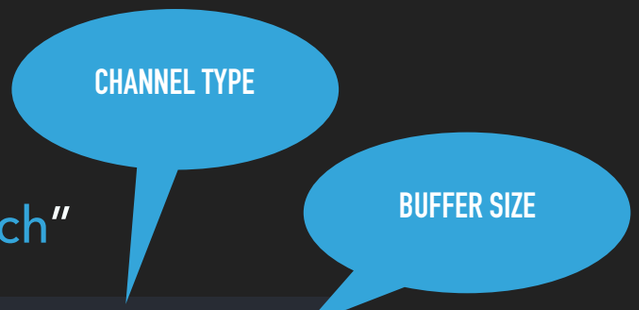
Data you wish to send to a Channel receiver

Output

Data received from a Channel sender

- Channels are a synchronization primitive in Go, normally used to communicate between goroutines.
- Variables can be put into a channel and then pulled out in “first in, first out” order (FIFO).
- The number of variables that can be stored in a channel is called the buffer size.
- When doing an insert, if the channel is full execution blocks until room is made.
- When receiving a variable, execution will block until a variable can be received.
- for/range can be used with a channel. This allows pulling of data until the channel is closed.
- A closed channel will return the Zero Value of the type stored in the channel.

CHANNELS



- Creates a channel “ch”

```
ch := make(chan string, 1)
```

- Puts “hello” into the channel

```
ch <- "hello"
```

- Pulls the next variable from the channel into x

```
x := <-ch
```

- Pulls a variable from the channel and stores it in item until the channel is closed.

```
for item := range ch {
  fmt.Println(item)
}
```

- Closes a channel

```
close(ch)
```

CHANNELS

```go
// printer reads ints off of input and prints it to the screen.  When the
// input channel closes and all data has been read off of input, the exit
// channel will be closed to signal that printer is done processing.
func printer(input chan int, exit chan bool) {
  defer close(exit)
  for i := range input {
    fmt.Println(i)
  }
}

func main() {
  input := make(chan int, 10)
  exit := make(chan bool)

  // Start our printer in a goroutine.
  go printer(input, exit)

  // Send 100 integers to our channel for printing.
  for i := 0; i < 100; i++ {
    input <- i
  }

  // Let the print know that we are no longer going to send data.
  close(input)

  // Wait for the printer to exit.
  <-exit
}
```

EXERCISE

- Create a function called doubler
  - Takes in two arguments:
    - "input" of type chan int
    - "output" of type chan int
  - It should read off of channel input, multiply the int by 2 and write the new number to output.
  - It should close output when the function exits.
- In main():
  - Create input and output channel of type chan int with a buffer of 10.
  - Use a goroutine to start a doubler(input, output)
  - Use a goroutine on an anonymous function to
    - Send the integers 1 to 100 to doubler via input
    - Close the input channel when done sending
  - Loop through the output channel and print the results.
- Answer at: https://play.golang.org/p/48cVucXiB3

WAIT GROUPS

- A WaitGroup is a counter that can only represent positive values. It is a synchronization primitive, so it can be used by multiple goroutines.
- WaitGroups are used to count the number of operations that are outstanding. For example, starting 20 goroutines and knowing when they are all done.
- You can add to a WaitGroup by using the .Add(n int) method.
- You can remove from a WaitGroup by using the .Done().
- If you call .Done() and the internal counter is 0, your program will panic.
- If you call .Wait(), your code will block until the WaitGroup's internal counter is 0.
- You cannot use an int for this, as this would cause a data race.

WAIT GROUPS

```go
func main() {
  wg := &sync.WaitGroup{}

  // Sping off 1000 goroutines, each one printing a number.
  for i := 0; i < 1000; i++ {
    wg.Add(1)  // Add 1 to the counter.  You MUST do this before the func().
    go func(i int) {
      defer wg.Done() // Remove 1 from the counter after the func() is finished.
      fmt.Println(i)
    }(i)
  }

  wg.Wait()  // Wait unil all of the goroutines are finished.
}
```

- This lets us spin off any number of goroutines and wait for them to finish.
- In normal use, we might continue doing other things and then use .Wait() when we need to stop to retrieve data or require all processing has completed before moving on.

MUTEXES

- A Mutex provides a simple locking mechanism.
  - If a function calls .Lock(), then any other function calling .Lock() on the same Mutex blocks.
  - Calling .Unlock() allows another function grab the lock.
- This can be used to prevent multiple goroutines from accessing the same variable at the same time.

```
var counter = 0

func increment(wg *sync.WaitGroup, mu *sync.Mutex) {
  mu.Lock()
  defer mu.Unlock()
  defer wg.Done()
  counter++
}

func main() {
  wg := &sync.WaitGroup{}
  mu := &sync.Mutex{}

  for i := 0; i < 1000; i++ {
    wg.Add(1)
    go increment(wg, mu)
  }

  wg.Wait()
  fmt.Println(counter)
}
```

EXERCISE

- Create a struct call Sum
  - Give it an attribute called sum of type int
  - Give it an attribute called mu of type sync.Mutex
  - Give it a method called Add(n int) that adds to n to sum, protected by mu.
- In main():
  - Create a variable called s of type *Sum
  - Create a variable called wg of type *sync.WaitGroup
  - Create a for loop that counts from 1 to 4
    - In each loop, use a goroutine to an anonymous function that:
      - Calls Add(i), where i is the number of the loop.
      - Defer's a wg.Done() call.
  - Use wg.Wait() to wait for the goroutines to finish.
  - Print out the sum, which should be 10.
- Answer at: https://play.golang.org/p/yZjiEU1b5P
- Note: Removing the mutex locks will do nothing in the playground, but will in real programs.

SELECT STATEMENT

- select is similar to switch, but is used to deal with input from multiple channels.
- With select, you can listen to multiple channels at the same time and operate on the one that has data on it.
- select will randomly choose a case statement if multiple channels have data.

SELECT STATEMENT

```
select {
case <- <channel var>:
  <statements to execute>
case <var> := <- <channel var>:
  <statements to execute>
default:
  <statements to execute>
}
```

Take data off channel, but do nothing with it

Take data off channel, assign it to <var>

If no channel has data, this executes

SELECT STATEMENT

```go
// printer prints a number divded by 2 if it comes on the half channel.
// It prints a number multiplied by 2 if it comes on the double channel.
// It terminates if it receives anything on exit.
func printer(half, double chan int, wg *sync.WaitGroup, exit chan bool) {
  for {
    select {
    case i := <-half:
      fmt.Printf("%d/2 = %d\n", i, i/2)
    case i := <-double:
      fmt.Printf("%d*2 = %d\n", i, i*2)
    case <-exit:
      fmt.Println("Quitting...")
      return
    }
    wg.Done()
  }
}
```

```go
func main() {
  half := make(chan int, 1)
  double := make(chan int, 1)
  exit := make(chan bool)
  wg := &sync.WaitGroup{}

  for i := 1; i < 11; i++ {
    i := i  // Make i scoped inside the for loop.
    wg.Add(1)
    go func(){
      half <- i
    }()

    wg.Add(1)
    go func() {
      double <- i
    }()
  }
  // This just prevents everything from being in order.  Ignore.
  time.Sleep(2 * time.Second)

  go printer(half, double, wg, exit)

  wg.Wait()
  close(exit)

  // Sleep enough time to let "Quitting" print.
  time.Sleep (2 * time.Second)
}
```

- Try it at: https://play.golang.org/p/GDzGHxiEKn

SELECT STATEMENT

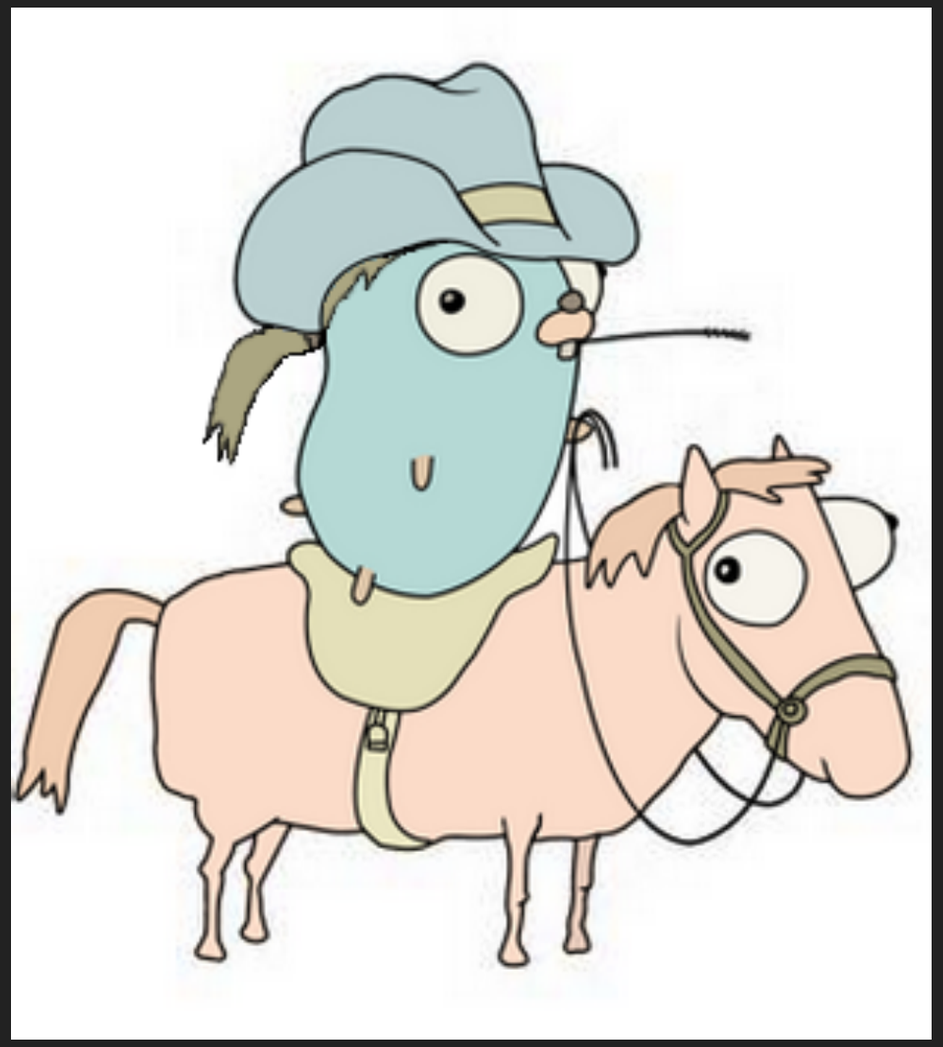
- Sometimes you want to only wait for a certain amount of time for something to happen on a channel.
- The time library provides a nice method to handle this.

```
select {
case <- <channel var>:
  <statements to execute>
case <-time.After(10 * time.Second):
  <statements to execute>
}
```

If something doesn't happen after 10 seconds, this executes

EXERCISE

- Write a function call printer(in chan string) (done chan bool)
  - Use make() to initialize the done channel.
  - Spin off a goroutine that:
    - defers closing the done channel.
    - Takes input off the in channel and prints it.
    - If printer does not receive input in 5 seconds:
      - The function should print “quitting…”
      - Return.
  - Return the done channel. Remember, the goroutine will keep running.
- In main():
  - Create a channel called in of type chan string with a buffer of 1.
  - Call done := printer(in)
  - Send “hello” to channel in.
  - Send “world to channel in.
  - Wait for the printer to die after 5 seconds by doing: <-done
- Answer at: https://play.golang.org/p/-80tpVoYlo



CONSTANTS

CONSTANTS ARE PROOF THAT GOD LOVES US AND WANTS US TO BE HAPPY.
– BENJAMIN FRANKLIN

CONSTANTS

- Constants store values that are set at compile time.
- Constants can represent boolean, rune, integer types, floating-point types, complex and string.
- Constants are declared using the const keyword.
  - const str = “hello world”
  - const num = 3
  - const num64 int64 = 3
- Constants can be typed or untyped. An untyped integer constant can be used with any integer variable. If typed, it can only be used with another of the same type.
- In many languages, it is common to see a constant name in all upper case. We do not do this in Go.

ENUMERATION VIA CONSTANTS

- The keyword iota can be used to create enumerators.

```
// Enumeration using constants.
const (
  apple = iota  // apple == 0
  orange // orange == 1
  pear  // pear == 2
)
```

BLANK INTERFACE

AN INTERFACE DOES NOT BECOME CONCRETE THROUGH MAGIC. IT TAKES SWEAT, DETERMINATION AND TYPE ASSERTION
– COLIN POWELL

BLANK INTERFACE

- A blank interface, designated as interface{}, can hold any value
- This allows Go to accept multiple different types as a single argument
- fmt.Println() is an example, it has the following signature:

```
func Println(a ...interface{}) (n int, err error)
```

BLANK INTERFACE

- However a blank interface{} has no methods and does not expose its value
- The interface must be converted into its concrete type or an interface type it satisfies via “type assertion”
- A type assertion can be done either via a type assertion statement or using a switch conditional

EXAMPLE

```go
var i interface{}
  // i = "hello world"
  i = 32
  // i = 0.0

  switch v := i.(type) {
  case string:
    fmt.Printf("%q was a string value\n", v)
  case int:
    fmt.Printf("%d was an int value\n", v)
  default:
    fmt.Printf("was not a supported type, was %T",  v)
  }

  if x, ok := i.(int); ok {
    fmt.Printf("the result of %d + 10 = %d\n", x, x+10)
  }
```

Try it out:

https://play.golang.org/p/dJAHcDBzjls

EXERCISE

SAVE THIS EXERCISE FOR USE LATER

- Write a function called PrintMapSlice()
  - Argument is an interface{}
  - Returns an error
  - Prints the key/values of a map[string]string, one per line
  - Prints the index/values of a []string slice, one per line
  - Prefixes the printed line with either “map: “ or “slice: “
  - Returns an error if any type other than a map[string]string or []string is passed.
  - Pass a map[string]string, []string, and any one other type to PrintMapSlice()
  - Answer at: https://play.golang.org/p/raqrFAghwsQ

EMBEDDING/ COMPOSITION

AVOID INHERITANCE;
IT HAS MANY SNARES AND NO REAL BENEFIT
– WILLIAM PEN

EMBEDDING

- Go does not have the notion of subclassing that many Object Oriented languages provide
- Go does provide the ability to “borrow” from another type via embedding one struct/interface within another struct/interface

Embedded Mutex

```
type Records struct {
  recs    []Record
  nextID int
  sync.Mutex // Embedded Mutex
}
```

```
recs.Lock()
recs.Add(Record{})
recs.Unlock()
```

Non-Embedded Mutex

```
type RecordsAlt struct {
  recs    []Record
  nextID int
  mu sync.Mutex
}
```

```
recs.mu.Lock()
recs.Add(Record{})
recs.mu.Unlock()
```

Embedding To Satisfy An Interface

```
type LockRec interface {
  Lock()
  Unlock()
  Add(Record)
}
```

```
var recs LockRec

recs = Records{}

recs = RecordsAlt{}
```

EMBEDDING

- This differs from subclassing in other languages in the following way:
  - While an embedded method is available on the outer object, when invoked the receiver is still the inner object, not the parent

EMBEDDING

- Initializing an embedded type in a struct is similar to other composite literal struct initializations

```
type Records struct {
  recs    []Record
  nextID int
  sync.Mutex // Embedded Mutex
}
```

```
// Allows assignment via named field for embedded type.
mu := sync.Mutex{}
recs := &Records{nextID: 1, Mutex: mu}

// Uses field order for naked assignment.
recs := &Records{[]Record{}, 0, sync.Mutex{}}

// Just uses the zero values.
recs := &Records{}
```

EMBEDDING

- Accessing fields within an embedded type with the same name a field in the parent is still possible
- Outer method/field names have precedence over inner names

```go
type Job struct {
  Command string
  *log.Logger
}

// Printf is overriding our embedded log.Logger.Printf().
func (job *Job) Printf(format string, args ...interface{}) {
  // We can still access it by using the type name as the field name.
  job.Logger.Printf("%q: %s", job.Command, fmt.Sprintf(format, args...))
}

func New(cmd string) *Job {
  return &Job{Command: cmd, Logger: log.New(os.Stderr, "Job: ", log.Ldate)}
}

func main() {
  j := New("ls -al /home/johndoak")
  j.Println("hello") // Uses the embedded Println()
  j.Printf("hello") // Uses the outer defined Printf(), not Logger.Printf()
  j.Logger.Printf("hello") // We can still acess Logger.Printf() if required
}
```

Try it at:

https://play.golang.org/p/9LjnJBEB6LU

EXAMPLE

```go
type Records struct {
  recs   []Record
  nextID int
  sync.Mutex // Embedded Mutex
}

func (r *Records) Add(rec Record) {
  rec.ID = r.nextID
  r.nextID++
  r.recs = append(r.recs, rec)
}

func (r *Records) Print() {
  for _, rec := range r.recs {
    fmt.Println(rec)
  }
}
```

```go
func main() {
  recs := &Records{}

  // No need for locking.
  for i := 0; i < 1000; i++ {
    recs.Add(Record{})
  }

  // Need locking.
  wg := sync.WaitGroup{}
  wg.Add(1000)
  for i := 0; i < 1000; i++ {
    go func() {
      defer wg.Done()
      recs.Lock()
      defer recs.Unlock()
      recs.Add(Record{})
    }()
  }
  wg.Wait()
  recs.Print()
}
```

Try it out:

https://play.golang.org/p/hfB5qp204Kw

COMPOSITION

- Interfaces like structs can embed other interfaces
- This allows for composite interfaces, that is an interface made of the union of multiple interfaces
- Only an interface can be embedded within an interface

```
type Reader interface {
    Read(p []byte) (n int, err error)
}

type Writer interface {
    Write(p []byte) (n int, err error)
}

// ReadWriter is the composition of the Reader and Writer interfaces.
type ReadWriter interface {
    Reader
    Writer
}
```

EXERCISE

- Create an interface called Reader
  - Has a single method called Read()
    - Returns a []byte and an error
    - Should return all bytes in an internal buffer and clear the buffer
- Create an interface called Writer
  - Has a single method called Write()
    - Takes a single argument of type []byte
    - Returns a single type, error
    - Appends to an internal buffer
- Create an interface called Locker
  - Has a method called Lock()
  - Had a method called Unlock()
- Create a composite interface called ReadWrite
  - Is a composite of Reader and Writer
- Create a composite interface called ReadWriteLock
  - Is a composite of ReadWrite and Locker
- Write an implementation of that can satisfy each off these:
  - Should embed a sync.Mutex or *sync.Mutex
  - Use the bytes.Buffer type internally
- Assign the implementation to a ReadWriteLock and try using it
- Answer at: https://play.golang.org/p/KS1oRNbJImo

WRITING TESTS

TESTS ARE PROOF THAT HELL DOES EXIST – EVERY DEVELOPER

TESTING PACKAGES

- Tests are located in *_test.go files
- Tests are normally part of the package they want to test. So if you want to test package ioutil, the ioutil_test.go file will have a package declaration of “ioutil”. This allows a test to test private functions/methods
- Each test is a function that starts with the name Test. So a test that tested a function called Add() might be called TestAdd()
- Each test function has the same signature:
  - func Test(t *testing.T) {}
- A test passes if t.Errorf() or t.Fatalf() is not called and the test does not time out
- t.Errorf() will cause the test to fail, but will not stop the test from running
- t.Fatalf() will cause the test to fail and exits that test function immediately

DO NOT USE MOCK LIBRARIES, USE FAKES

- Mocks are defined to be automatically generated code that is used to record expected method calls and return controlled output
- Mocks are generally just bad in any language
- Usually brittle (change call order during refactor or a multitude of other factors)
- Use of reflection can fail in unexpected and hard to understand ways
- Packages like gomock have been deprecated at the places that they were developed at

DO NOT USE MOCK LIBRARIES, USE INTERFACES

- If you need to test interactions with external systems, hide them behind private interfaces
- Create fakes that only include the methods that you use, not all the methods of the concrete type
- Provide fake implementations that simply test your function by either returning an error or test output for the function to process
- If providing a fake for a 3rd party interface, use composition to protect your fake by including the existing interface in your fake as an anonymous attribute
- Storage systems, the most common complex fake, should be abstracted behind an interface
  - Allows simple file implementations or in-memory implementations to be used in tests
  - Testing concrete implementations almost always requires either:
    - Using containers to setup a test environment to test the concrete methods
    - Test instances with the cloud provider that can be brought up and down via scripts (Azure CosmosDB for example)
  - Tests that do not interact with external systems are "hermetic". All tests not testing a concrete implementation should be hermetic. Test the bare essentials in non-hermetic tests, they are expensive!
- RPC implementations are easily faked, but this is beyond the scope of this tutorial

GO USES TABLE DRIVEN TESTS

- The most common test methodology used in Go is the “table driven test”
- A “table” is defined as a list of structs
- Each struct defines the test description, the test input to the function and the expected result
- The test loops through each entry in the table passing the input and retrieving the output. The test compares the received output to the expected output
- This makes for readable tests that separate the test data from the test method

EXAMPLE

```go
func Divide(n int, d int) (float64, error) {
  if d == 0 {
    return 0.0, fmt.Errorf("cannot divide by 0")
  }
  return float64(n)/float64(d), nil
}

func TestDivide(t *testing.T) {
  tests := []struct{
    desc string
    n int
    d int
    err bool
    want float64
  }{
    {"divide by 0 error", 10, 0, true, 0.0},
    {"success", 10, 3, false, float64(10)/float64(3)},
  }

  for _, test := range tests {
    got, err := Divide(test.n, test.d)
    switch {
    case err == nil && test.err:
      t.Errorf("TestDivide(%s): got err == nil, want err != nil", test.desc)
      continue
    case err != nil && !test.err:
      t.Errorf("TestDivide(%s): got err == %s, want err == nil", test.desc, err)
      continue
    case err != nil:
      continue
    }
    if got != test.want {
      t.Errorf("TestDivide(%s): got %v, want %v", test.desc, got, test.want)
    }
  }
}
```

Try it out:

https://play.golang.org/p/VQ9ggHVvXsQ

COMPLEX EXAMPLE

- Has Storage interface to define access to storage (could be a database, file system, or in-memory representation)
- A concrete fakeStorage for use in tests
- A Registrar type that accesses Records in Storage, supporting concurrent access
- Tests the Read() method via a Table Driven Test

See it here:

https://play.golang.org/p/tAk8FqPDtgq

EXERCISE

- Load the exercise from section 20, the PrintMapSlice exercise
- Write a table driven test that tests various inputs to expected outputs
- You will need to change to using fmt.Fprintln()/Fprintf() instead of fmt.Println()/Printf()
  - You may use a *bytes.Buffer for the io.Writer type
  - Use a private global to store the *bytes.Buffer as an io.Writer type
- Answer at: https://play.golang.org/p/pvsmGibaGYQ

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- Billboard graphic: "Designed by Freepik", at www.freepik.com
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