Golang Programming

Composite types, functions, error handling

Where to Find The Code and Materials?

https://github.com/iproduct/coursego

Arrays

- Example:

```
var a [10]int
for i := 0; i < 10; i++ {
      fmt.Printf("Element: a[%d] = %d\n", i, a[i])
}
```

- In Go, arrays are a low-level data structure - blocks of memory.
- In C, array subscripting is just another way of writing pointer arithmetic, but Go does not permit pointer arithmetic - pointers and arrays are distinct types => no arbitrary-sized array.
- The size of a Go array is intrinsic to its type, automatic bounds checking.

Initializing Arrays

- Creating array of size 50 filled with zeros:

```
var a1 [50]int
```

- Creating 2-D matrix 5x5:

```
var matrix [5][5]float64
```

- Initializing array using array literal:

```
primes := [6]int{2, 3, 5, 7, 11, 13}
```

Length and capacity

```go
var a [2]string
a[0] = "Hello"
a[1] = "World"
fmt.Println(a[0], a[1])
fmt.Println(len(a))
fmt.Println(cap(a))
```

```
Results:
```

Hello World

2

2

Assigning Array Values

- Assigning array value copies that value (potentially very slow):

```
a1 := [...]int{1, 2}
a2 := a1
a2[0] = 3
fmt.Printf("%v, %v, %t\n", a1, a2, &a1 == &a2)
```

`Result:` [1 2], [3 2], false

- Go makes it possible to write fast code, but makes it easy to write correct code. This is the opposite of the C philosophy, which makes it easy to write fast code and possible to write correct code. [Chisnall, The Go Programming Language Phrasebook]

Slices

- Create by slicing existing array:

```
var a3[20]int
firstHalf := a3[:10]
secondHalf := a3[10:]
middle := a3[5:15]
all := a3[:]
fmt.Printf("%v, %v, %v, %v\n", firstHalf, secondHalf, middle, all)
```

- Create using composite literal and by re-slicing:

```
var slice []int = []int{2, 3, 5, 7, 11, 13}
fmt.Println(slice) // [2 3 5 7 11 13]
reslice := slice[2:5]
fmt.Println(reslice) // [5 7 11]
```

Making Slices, Maps and Channels

Call	Type T	Result
make(T, n)	slice	slice of type T with length n and capacity n
make(T, n, m)	slice	slice of type T with length n and capacity m
make(T)	map	map of type T
make(T, n)	map	map of type T with initial space for approximately n elements
make(T)	channel	unbuffered channel of type T
make(T, n)	channel	buffered channel of type T, buffer size n

Making Slices and Reslicing

```go
func main() {
	a := make([]int, 5)  // len(a)=5
	printSlice("a", a) // a len=5 cap=5 [0 0 0 0 0]
	b := make([]int, 0, 5) // len(b)=0, cap(b)=5
	printSlice("b", b) // b len=0 cap=5 []
	b = b[:cap(b)] // len(b)=5, cap(b)=5
	printSlice("b", b) // b len=5 cap=5 [0 0 0 0 0]
	b = b[1:]      // len(b)=4, cap(b)=4
	printSlice("b", b) // b len=4 cap=4 [0 0 0 0]
}

func printSlice(s string, x []int) {
	fmt.Printf("%s len=%d cap=%d %v\n", s, len(x), cap(x), x)
}
```

Making Slices and Reslicing

```go
func main() {
	a := make([]int, 5, 10)
	printSlice("a", a)          // a len=5 cap=10 [0 0 0 0 0]
	b := make([]int, 0, 5)
	printSlice("b", b)          // b len=0 cap=5 []
	c := b[:2]
	printSlice("c", c)          // c len=2 cap=5 [0 0]
	d := c[2:4:5]
	printSlice("d", d)          // d len=2 cap=3 [0 0]
	e := a[2:5:10]
	printSlice("e", e)          // e len=3 cap=8 [0 0 0]
}
func printSlice(s string, x []int) {
	fmt.Printf("%s len=%d cap=%d %v\n", s, len(x), cap(x), x)
}
```

Slices Are Like References to Arrays

```go
func main() {
	names := [4]string{"John", "Paul", "George", "Ringo"}
	fmt.Println(names) // [John Paul George Ringo]

	a := names[1:2]
	b := a[2:3]
	fmt.Println(a, b) // [Paul] [Ringo]
	b[0] = "XXX"
	fmt.Println(a, b)  // [Paul] [XXX]
	fmt.Println(names) // [John Paul George XXX]
}
```

Nil Slices

```
func main() {
	var s []int
	fmt.Println(s, len(s), cap(s)) // [] 0 0
	if s == nil {
		fmt.Println("nil!") // nil!
	}
}
```

Slices of Slice

```go
// Create a tic-tac-toe board.
board := [][]string{
	[]string{"_", "_", "_"},
	[]string{"_", "_", "_"},
	[]string{"_", "_", "_"},
}

// The players take turns.
board[0][0] = "X"
board[2][2] = "O"
board[1][2] = "X"
board[1][0] = "O"
board[0][2] = "X"

for i := 0; i < len(board); i++ {
	fmt.Printf("%s\n", strings.Join(board[i], " "))
}
```

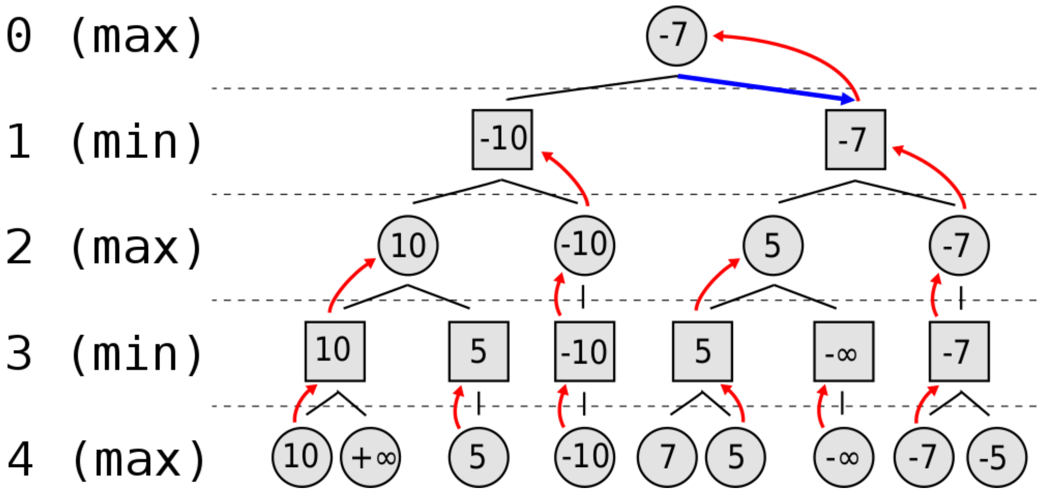
Exercise 1: Tic-Tac-Toe

- Implement Tic-Tac-Toe game with two participants. You can use the last example as a base.
- The two players should in turn enter their moves from the console and the program should validate them and print the resulting board or print an error message if the move is illegal.

- ** Advanced: Try to implement in Go an algorithm for that will automatically choose the next move of a computerized player – e.g. using Minimax procedure: https://en.wikipedia.org/wiki/Minimax*

Minimax Procedure

```
function minimax(node, depth, maximizingPlayer):
    if depth = 0 or node is a terminal node then
        return the heuristic value of node
    if maximizingPlayer then
        value := −∞
        for each child of node do
            value := max(value, minimax(child, depth − 1, FALSE))
        return value
    else (* minimizing player *)
        value := +∞
        for each child of node do
            value := min(value, minimax(child, depth − 1, TRUE))
        return value
(* Initial call *)
minimax(origin, depth, TRUE)
```



	B chooses B1	B chooses B2	B chooses B3
A chooses A1	+3	−2	+2
A chooses A2	−1	0	+4
A chooses A3	−4	−3	+1

More Examples

```go
q := []int{2, 3, 5, 7, 11, 13}
fmt.Println(q) // [2 3 5 7 11 13]

r := []bool{true, false, true, true, false, true}
fmt.Println(r) // [true false true true false true]

s := []struct {
        i int
        b bool
}{
        {2, true},
        {3, false},
        {5, true},
        {7, true},
        {11, false},
        {13, true},
}
fmt.Println(s) // [{2 true} {3 false} {5 true} {7 true} {11 false} {13 true}]
```

Appending to a Slice

```
var s []int
printSlice(s) // len=0 cap=0 []
s2 := append(s, 0) // append works on nil slices.
printSlice(s2) // len=1 cap=1 [0]
s3 := append(s2, 1) // The slice grows as needed.
printSlice(s3) // len=2 cap=2 [0 1]
fmt.Printf("Same array: %t\n", &s3[0] == &s2[0]) // Same array: false

a := [...]int{2,3,5,7,9}
s4 := a[1:3]
printSlice(s4) // len=2 cap=4 [3 5]
s5 := append(s4, 11, 13)
printSlice(s5) // len=4 cap=4 [3 5 11 13]
fmt.Printf("Same array: %t\n", &s5[0] == &s4[0]) // Same array: true
s6 := append(s5, 17)
printSlice(s6) // len=5 cap=8 [3 5 11 13 17]
fmt.Printf("Same array: %t\n", &s6[0] == &s5[0]) // // Same array: false
```

Slice Range

```go
var pow = []int{1, 2, 4, 8, 16, 32, 64, 128}

func main() {
	for i, v := range pow {
		fmt.Printf("2**%d = %d\n", i, v)
	}
}
```

```go
func main() {
	pow := make([]int, 10)
	for i := range pow {
		pow[i] = 1 << uint(i) // == 2**i
	}
	for _, value := range pow {
		fmt.Printf("%d\n", value)
	}
}
```

Go Slices: Usage and Internals [Go Blog]

https://blog.golang.org/go-slices-usage-and-internals

Exercise 2: Drawing an Image

- Implement Pic. It should return a slice of length dy, each element of which is a slice of dx 8-bit unsigned integers. When you run the program, it will display your picture, interpreting the integers as grayscale (well, bluescale) values.
- The choice of image is up to you. Interesting functions include (x+y)/2, x*y and x^y.
- You need to use a loop to allocate each []uint8 inside the [][]uint8.

```go
package main
import ("github.com/iproduct/coursego/simple/mypic“; "log“; "os“; "path")
const baseDir = "d:/CourseGO/workspace/src/github.com/iproduct/coursego/image"
// Pic returns a grayscale pic of size dy * dx
func Pic(dx, dy int) [][]uint8 {
}
func main() {
	file, err := os.Create(path.Join(baseDir, "image.png"))
	defer file.Close()
	if err != nil { log.Fatal(err) }
	mypic.Encode(Pic, file)
}
```

Maps

```
type Vertex struct {
	Lat, Long float64
}

var m map[string]Vertex

func main() {
	m = make(map[string]Vertex)
	m["Bell Labs"] = Vertex{
		40.68433, -74.39967,
	}
	fmt.Println(m["Bell Labs"])
}
```

Maps Literals

```
type Vertex struct {
	Lat, Long float64
}

var m = map[string]Vertex{
	"Bell Labs": Vertex{ 40.68433, -74.39967 },
	"Google“ :   Vertex{ 37.42202, -122.08408 },
}

func main() {
	fmt.Println(m)
}
```

Maps Literals Shortcut

```
type Vertex struct {
	Lat, Long float64
}

var m = map[string]Vertex{
	"Bell Labs": {40.68433, -74.39967},
	"Google":    {37.42202, -122.08408},
}


func main() {
	fmt.Println(m)
}
```

Mutating Maps

- ```go
  m := make(map[string]int)

  m["Answer"] = 42
  fmt.Println("The value:", m["Answer"]) // The value: 42

  m["Answer"] = 48
  fmt.Println("The value:", m["Answer"]) // The value: 48

  delete(m, "Answer")
  fmt.Println("The value:", m["Answer"]) // The value: 0

  v, ok := m["Answer"]
  fmt.Println("The value:", v, "Present?", ok) // 0 Present? false
  ```
  ```

Exercise 3: Word Counting

- Implement WordCount. It should return a map of the counts of each “word” in the string s. The wc.Test function runs a test suite against the provided function and prints success or failure. (You might find strings.Fields helpful):

```go
package main
import (
	"golang.org/x/tour/wc"
)
func WordCount(s string) map[string]int {
	return map[string]int{"x": 1}
}
func main() {
	wc.Test(WordCount)
}
```

Map Ranges

```
func countLines(f *os.File, counts map[string]int) {
	input := bufio.NewScanner(f)
	for input.Scan() {
		counts[input.Text()]++
	}
}

func main() {
	files := os.Args[1:]
	counts := make(map[string]int)
	countLines(os.Stdin, counts)
	for key, val := range counts {
		fmt.Printf("%-20.20s -> %5d\n", key, val)
	}
}
```

Structs

```
type Vertex struct{ X, Y int }
type Line struct{ A, B *Vertex }
var gv Vertex = Vertex{2, 5}
var gv2 Vertex = Vertex{12, 29}
var gl Line = Line{&gv, &gv2}

func test(l Line) {
	fmt.Printf("%v, same=%v\n", l, l.A == gl.A)
	l.B.X = 42
	fmt.Printf("%v, %v\n", *l.A, *l.B)
}
func main() {
	test(gl)
	fmt.Printf("%v, %v\n", *gl.A, *gl.B)
}
```

Struct Literals

```
type Vertex struct {  X, Y int }

var (
	v1 = Vertex{1, 2}  // has type Vertex
	v2 = Vertex{X: 1}  // Y:0 is implicit
	v3 = Vertex{}      // X:0 and Y:0
	p  = &Vertex{1, 2} // has type *Vertex
)

func main() {
	fmt.Println(v1, p, v2, v3) // {1 2} &{1 2} {1 0} {0 0}
	p := &v1
	p.X = 1e9
	fmt.Println(v1) // {1000000000 2}
}
```

Recursion

```go
//This fact function calls itself until it reaches the base case
//of fact(0).
func fact(n int) int {
    if n == 0 {
        return 1
    }
    return n * fact(n-1)
}
func main() {
    fmt.Println(fact(7))
}
```

Functions – multiple return values

```go
func swap(x, y string) (string, string) {
	return y, x
}

func main() {
	a, b := swap("hello", "world")
	fmt.Println(a, b)
}
```

Functions - named return values

```go
func split(sum int) (x, y int) {
	x = sum * 4 / 9
	y = sum - x
	return
}

func main() {
	fmt.Println(split(17))
}
```

Value and Reference Parameters

- ```
  func swapVal(x, y string) (string, string) {
      return y, x
  }
  func swapRef(x, y *string) {
      *x, *y = *y, *x
  }

  func main() {
      a, b := swapVal("hello", "world")
      fmt.Println(a, b)
      swapRef(&a, &b)
      fmt.Println(a, b)
  }
  ```

Output:

world hello
hello world
  ```

Variadic Parameters

```go
func printf(format string, args ...interface{}) (int, error) {
	_, err := fmt.Printf(format, args...)
	return len(args), err
}

func main() {
	argsLen, err := printf("%v, %v\n", "abcd", 15)
	if err == nil {
		printf("Number args: %d\n", argsLen)
	} else {
		fmt.Printf("Error: %v\n", err)
	}
}
```

Function Values,Anonymous Functions, Closures

```
count := 0
inc := func() int {
      count++
      return count
}

incBy := func(n int) int {
      count += n
      return count
}

printf("%d\n", inc())
printf("%d\n", incBy(10))
```

Deferred Function Calls

```
func main() {
      defer fmt.Println("world")

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

Results:

hello

world

Stacking Deferred Function Calls

- ```go
  func main() {
      fmt.Println("counting")

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

      fmt.Println("done")
  }
  ```

```
Results: ?
```
```

Error Handling Strategies

- Propagate the error, so that the failure of the subroutine becomes caller's failure. Using fmt.Errorf function formats and returns a new error value possibly extending the error description with more context.
- Retry the failed operation, possibly with (exponential) delay between tries
- Print the error and stop the program gracefully – log.Fatal() / os.Exit(1)
- Just log the error and then continue, possibly with alternative approach
- Using panic() and recover()
- More about error handling in Go:

https://blog.golang.org/error-handling-and-go

https://golang.org/doc/effective_go.html#errors

Errors [https://golang.org/pkg/errors/, https://blog.golang.org/go1.13-errors]

```go
type MyError struct {
	When time.Time
	What string
}
func (e *MyError) Error() string {
	return fmt.Sprintf("at %v, %s",
		e.When, e.What)
}
func run() error {
	return &MyError{
		time.Now(),
		"it didn't work",
	}
}
func main() {
	if err := run(); err != nil {
		fmt.Println(err)
	}
}
```

Errors Summary

- Errors should implement the built-in, universally accessible error interface:

```
type error interface {
        Error() string
}
```

- They can have additional fields capturing the complete error context - Ex:

```
type PathError struct {
        Op string     // "open", "unlink", etc.
        Path string   // The associated file.
        Err error     // Returned by the system call.
}
func (e *PathError) Error() string {
        return e.Op + " " + e.Path + ": " + e.Err.Error()
}
```

- Callers that care about the error details can use a type switch or assertion:

```
if e, ok := err.(*os.PathError); ok && e.Err == syscall.ENOSPC { ...
```

Example Handling PathError

```go
for try := 0; try < 2; try++ {
	file, err := os.Create(filename)
	if err == nil {
		return
	}
	if e, ok := err.(*os.PathError); ok && e.Err == syscall.ENOSPC {
		deleteTempFiles()  // Recover some space.
		continue
	}
	return
}

// Do something useful with the created file ...
```

Panic [https://golang.org/doc/effective_go.html#panic]

```
func badFunction() {
	fmt.Printf("Select Panic type (0=no, 1=int, 2= panic)\n")
	var choice int
	fmt.Scanf("%d", &choice)
	switch choice {
	  case 1:
		panic(0)
	  case 2:
		var invalid func();
		invalid()
	}
}
```

Recover [https://golang.org/doc/effective_go.html#recover]

```
func main() {
	defer func() {
		if x := recover(); x != nil {
			switch x.(type) {
			default:
				panic(x)
			case int:
				fmt.Printf("Function panicked with an error: %d\n", x)
			}
		}
	}()
	badFunction()
	fmt.Printf("Program exited normally\n")
}
```

Using Panic/Recover to Shut Down Failng Goroutine

```go
func server(workChan <-chan *Work) {
	for work := range workChan {
		go safelyDo(work)
	}
}

func safelyDo(work *Work) {
	defer func() {
		if err := recover(); err != nil {
			log.Println("work failed:", err)
		}
	}()
	do(work)
}
```

Converting Panic to Error at API Boundary (regex)

```go
// Error is the type of a regex parse error; it satisfies the error interface.
type Error string
func (e Error) Error() string {
	return string(e)
}
// error is a method of *Regexp that reports parsing errors by panicking with an Error.
func (regexp *Regexp) error(err string) {
	panic(Error(err))
}
// Compile returns a parsed representation of the regular expression.
func Compile(str string) (regexp *Regexp, err error) {
	regexp = new(Regexp)
	// doParse will panic if there is a parse error.
	defer func() {
		if e := recover(); e != nil {
			regexp = nil    // Clear return value.
			err = e.(Error) // Will re-panic if not a parse error.
		}
	}()
	return regexp.doParse(str), nil
}
```

Homework 2 (GitHub API Client)

Implement GItHub API HTTP client that will:

- Read a text file given as command line argument to the program and parse different Github usernames – each username on separate line in the file
- Fetch GitHub users data in JSON format using public GitHub API: https://api.github.com/users/${username}
- Fetch GitHub user repositories data in JSON format from: https://api.github.com/users/${username}/repos
- Fetch information about programming languages in each repo from: https://api.github.com/repos/${username}/${repo-name}/languages
- Parse the JSON data using json.Unmarshal into appropriate data structures in Go (you could define only fields that are interesting, all fields exported = starting with capital letter).
- Print a statistics report containing the information about the user, the number of user repositories, the distribution of programming languages according to their usage numbers (third URL), the total number of followers, number of forks for all repositories, by year distribution of user activity calculated using repositories creation and last update dates. Format the report and print it to the console as a table with all users to allow comparison.

Recommended Literature

- The Go Documentation - https://golang.org/doc/
- The Go Bible: Effective Go - https://golang.org/doc/effective_go.html
- David Chisnall, *The Go Programming Language Phrasebook*, Addison Wesley, 2012
- Alan A. A. Donovan, Brian W. Kernighan, *The Go Programming Language*, Addison Wesley, 2016
- Nathan Youngman, Roger Peppé, *Get Programming with Go*, Manning, 2018
- Naren Yellavula, *Building RESTful Web Services with Go*, Packt, 2017

Thank's for Your Attention!

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