Study Note: Introducing GO (O'Reilly)

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Ch1: Getting Started

GO Introduction

- Strong typed (static) language
- GO= programming language + toolset
- every go program starts with package declaration
  - package main
- Types of GO programs: executable and libraries
- import statement
  - import "fmt"
  - import ("fmt ; "reflect")

GO Environment

- ***go env***: list go environment setting
- GOPATH: environment var to find your source code and 3rd-party packages
    - directory structures: $GOPATH/src , /$GOPATH/pkg
    - setup GOPATH as home dir (linux / MAC OSX)
        - echo 'export GOPATH=$HOME\n' >> ~/.bashrc
            - will overwrite go env variables
- Other env: http://wiki.jikexueyuan.com/project/go-command-tutorial/0.14.html

GO DOC

- goodc: built-in documentation tool
    - godoc fmt Println

Ch2: Types

Primitive Types

- Integer types:
  - *uint8, uint16, uint32, uint64, int8, int16, int32, int64*
  - alias: *uint8=byte*, *rune=int32*
- Machine dependent types: *uint, int, uintptr*
  - always use int when working with integers
- Floating points: *float32, float64*
- Boolean: *bool* (*true* / *false*)
- String type: *string*

Print Data Types

- var a = 1
  var b = 0.5
  var c = [4]int { 1, 2, 3 , 4}
  var d = "hello"

- fmt.**Println**("a is", a, " b is ", b, " c is ", c , " d is ", d)

  - or fmt.**Print**

- fmt.**Printf**("a is %d b is %f c is %v d is %s\n", a, b, c, d)

- fmt.**Printf**("a is %v b is %v c is %v d is %v\n", a, b, c, d)

  - %v : general data types

Ch3: Variables

Var Declaration

- var x T
  - declare only variable ; cannot be used before memory allocation
- x := … (No T ; type inferred by compiler)
  - declare and allocate memory
- var (
  a = 5
  b = 10
  c = 15)
- const data (replace *var* with *const*)
  - const x string = "A const string"

Ch4: Control Structures

Loop

- for i:=1 ; i< 10; i++ {

      ….

  }

- infinite loop (no while syntax in GO)

  for {

      ….

  }

Branching

- if i == 1 { …
  } else if i == 2 { // else if must be at the same line as }
  …
  } else { // else must be at the same line as }
  …
  }

- switch i {
  case 0: …
  case 1: …
  default: … // no break is needed as C language
  }

Ch5 Arrays, Slices and Maps

Arrays

- declaration:
  - var x [5]int
  - var x = [5]int { 1, 2, 3, 4, 5 }
  - var x = […]int { 1, 2, 3, 4, 5 } // let compiler count for you
- [5]int and [4]int are two different data types
  - passing them to functions means copy array
    - GO Argument passing: ***call by value***
    - pass array's ***pointer*** to avoid copy

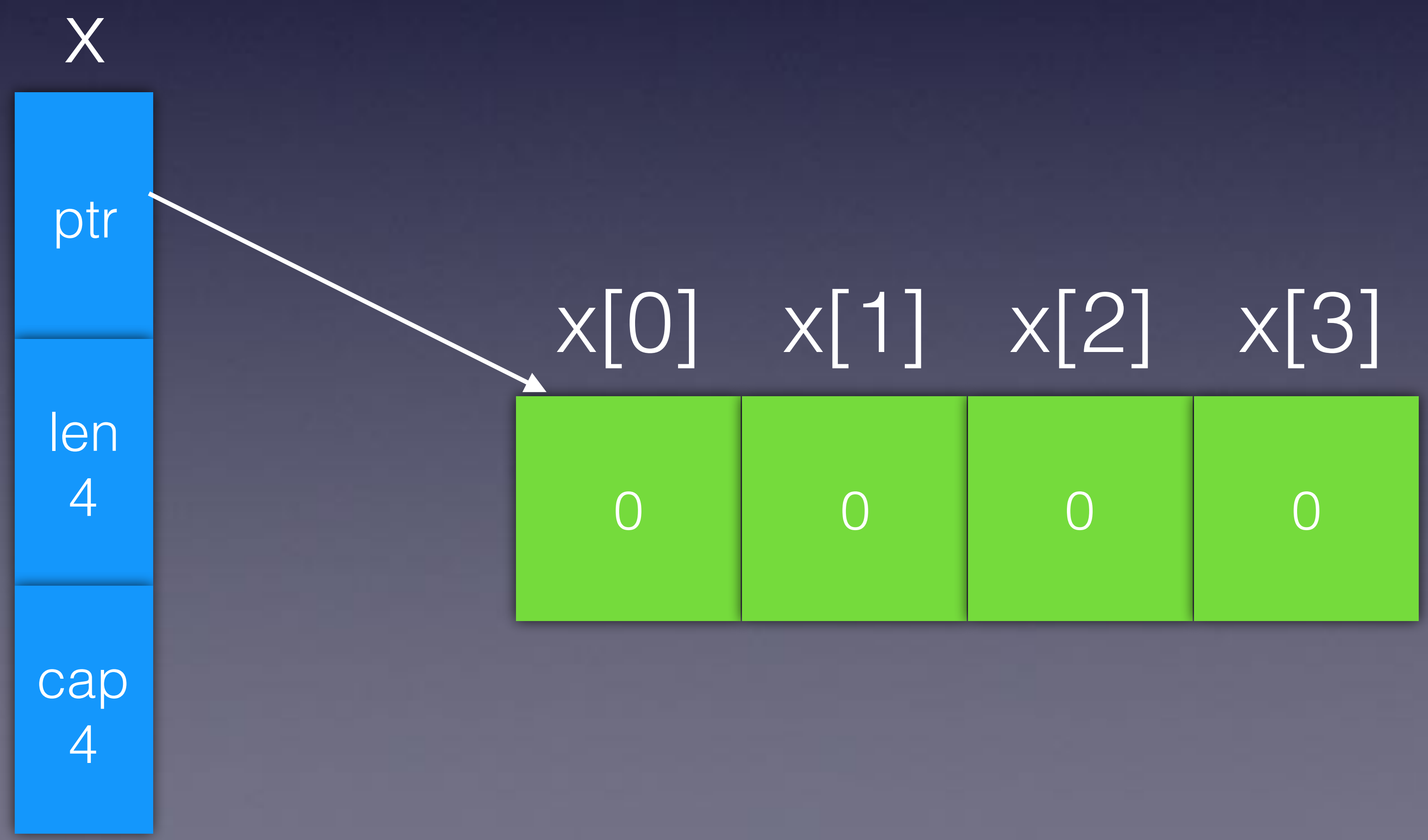
Visiting Arrays

- var b = [...] { 1, 2, 3, 4, 5 }
  - ```
    for idx, v := range b {
        fmt.Println(idx, v)
    }
    ```
  - ```
    for _, v := range b {
        // if index not used, skip it with _ to avoid compile error
        fmt.Println(v)
    }
    ```
  - ```
    for i:=0; i < len(b); i++ ) {
        fmt.Println(b[i])
    }
    ```
    ```

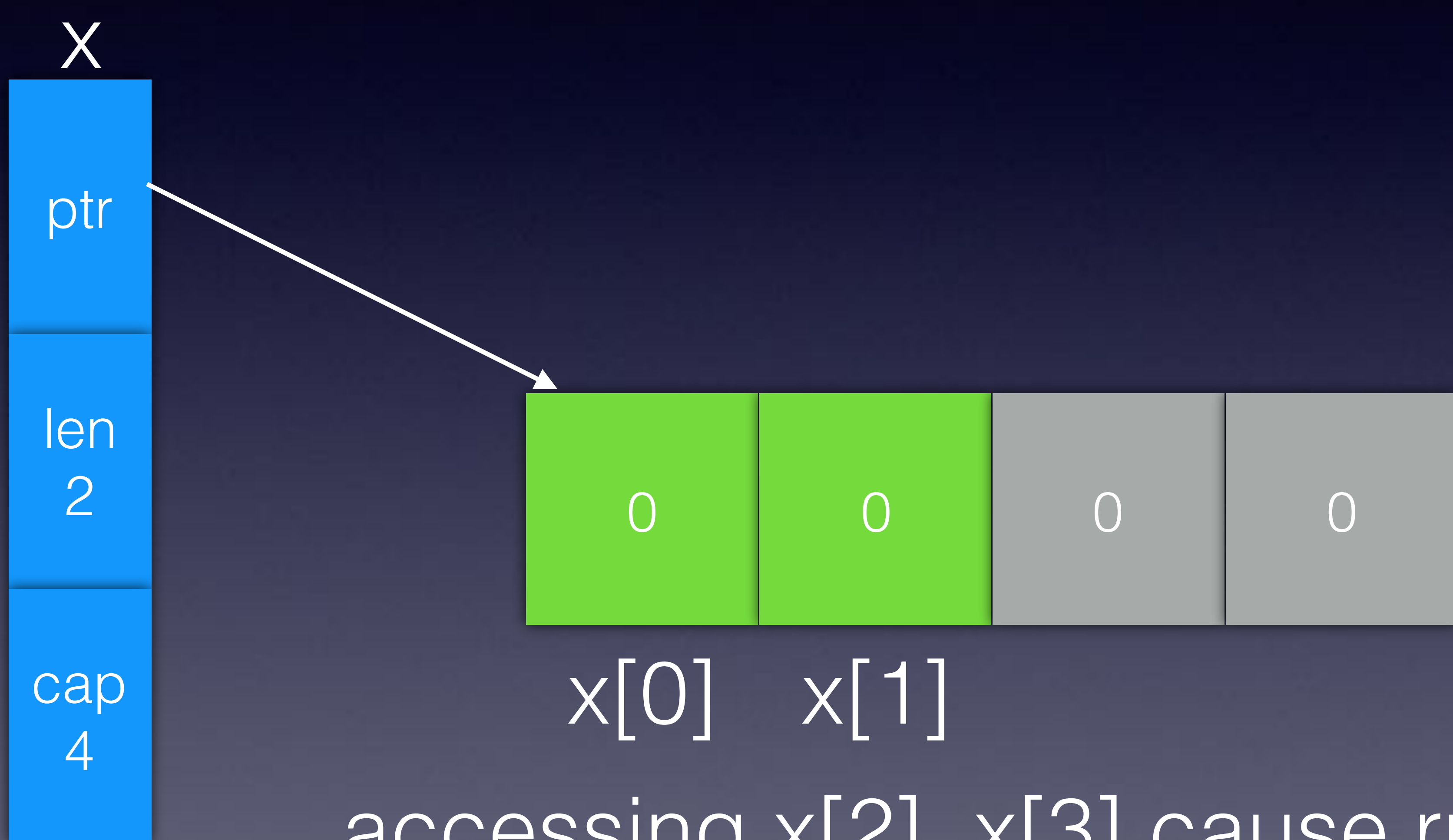
Slices

- A data structure
  - Pointer: a pointer to underlying array
  - Length: length of data currently pointed to (logical boundary)
  - Capacity: number of actual elements in underlying array (beginning at element referred by pointer)
- Functionality:
  - Simulate "dynamic array" (ex. C++ vector)
    - var x = make([]int, 2, 4) // make a slice with len 2, cap 4
  - Access sub-part of an array
    - var y = x[2:] // x[2] to x end

var x := make([]int, 4)
(Equals: var x:= make([]int, 4, 4)

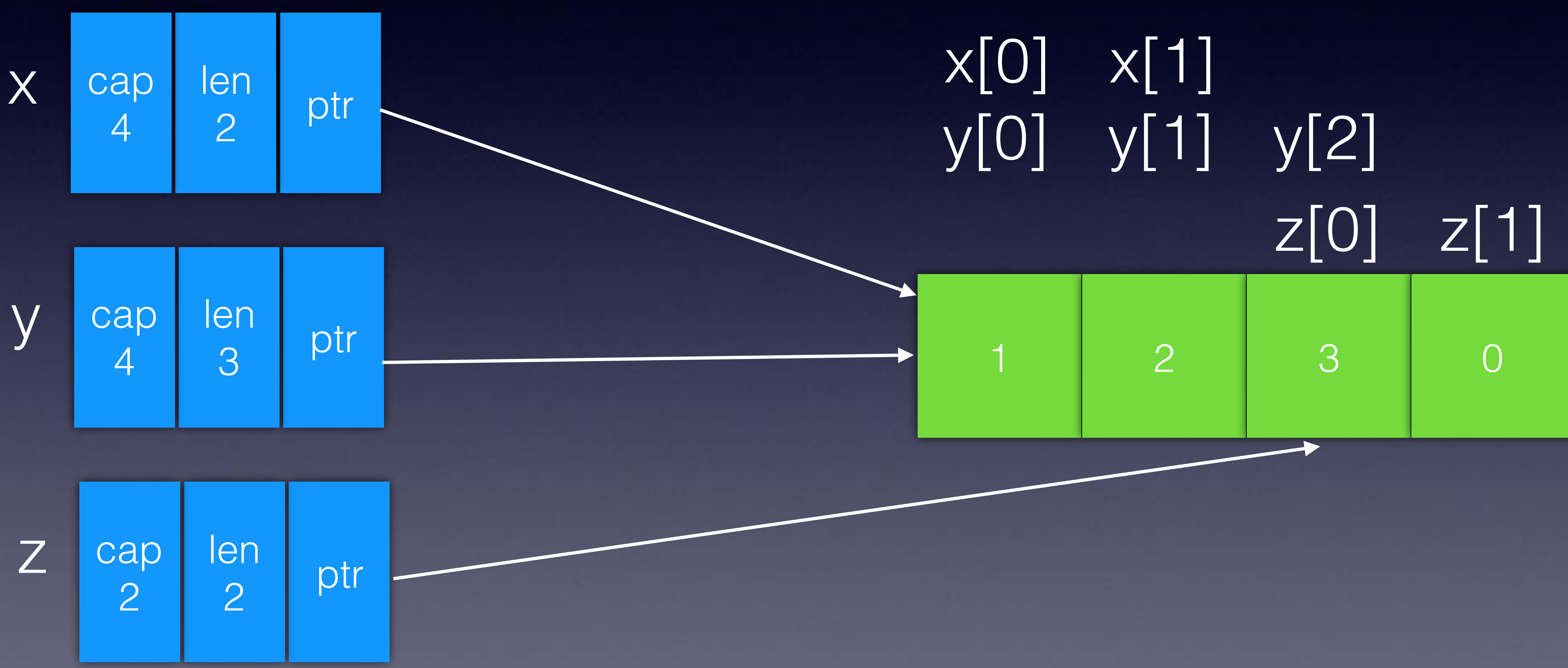


var x := make([]int, 2, 4)



accessing x[2], x[3] cause runtime error, since
logical length of x is 2
4 is physical length

```
var x := make([]int, 2, 4)
var y:= x[:3]
var z:=x[2:4]
x[0]=1
y[1]=2
z[0]=3
```

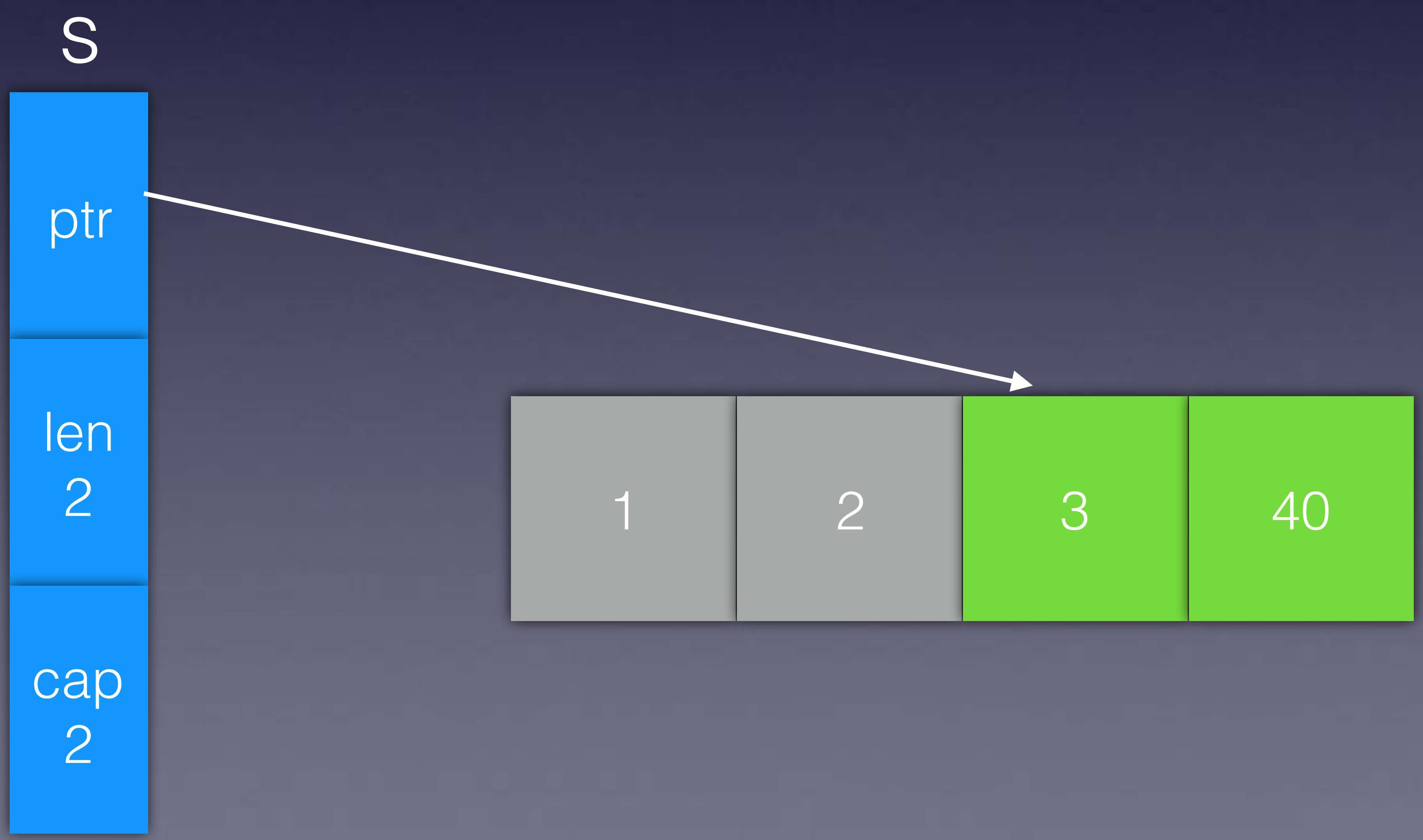


note: cap=number of physical elements beginning from element pointed to
note: _:= x[2:] cause panic error since x[2] does not exist (while x[:2] is ok)

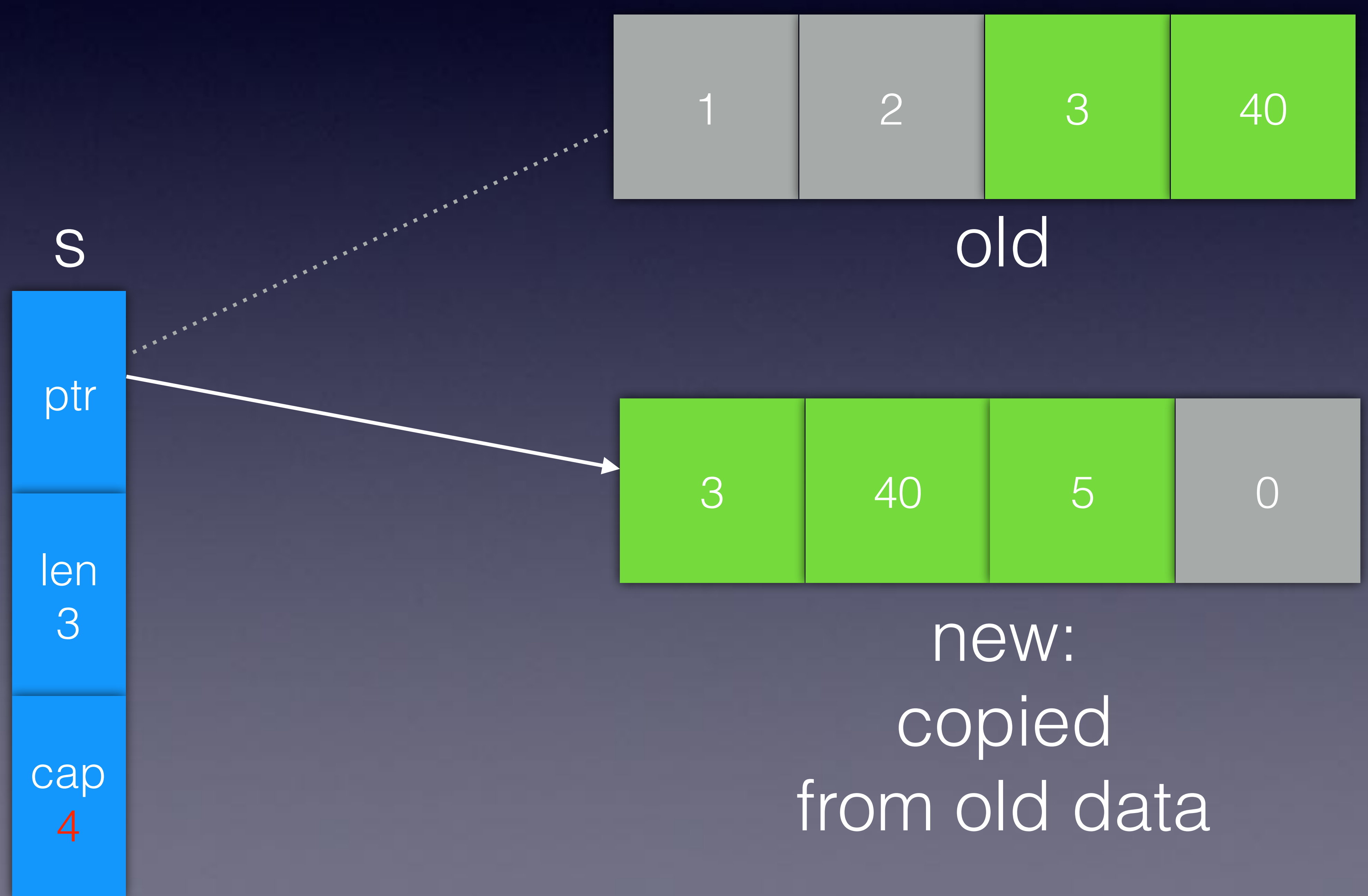
Expanding Slice

- New array will be allocated and old data is copied from old array, and slice is detached from old array to new array

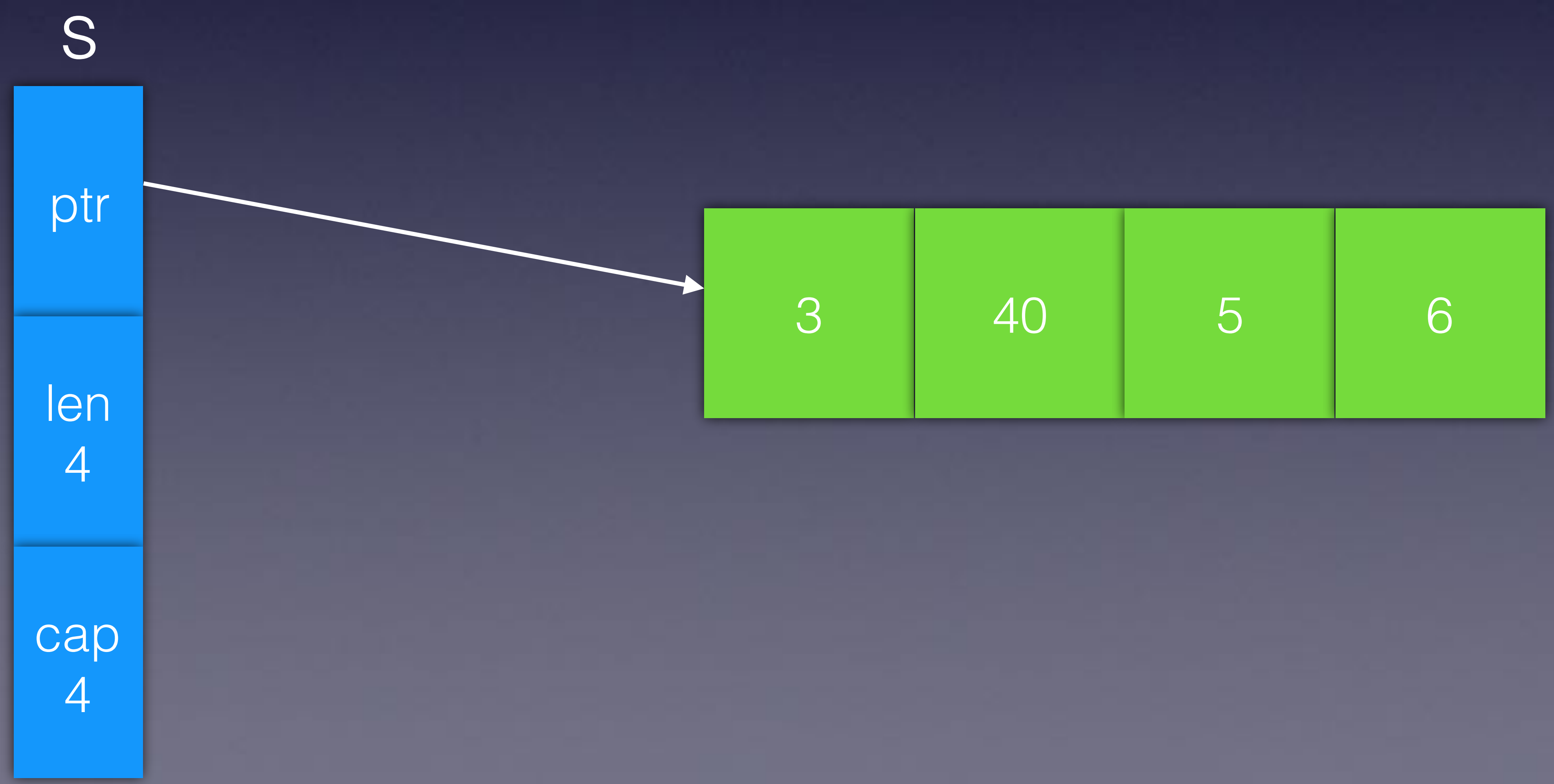
```
var b = [...]int{ 1, 2, 3, 4 }
s:= b[2:]
s[1]*= 10
```



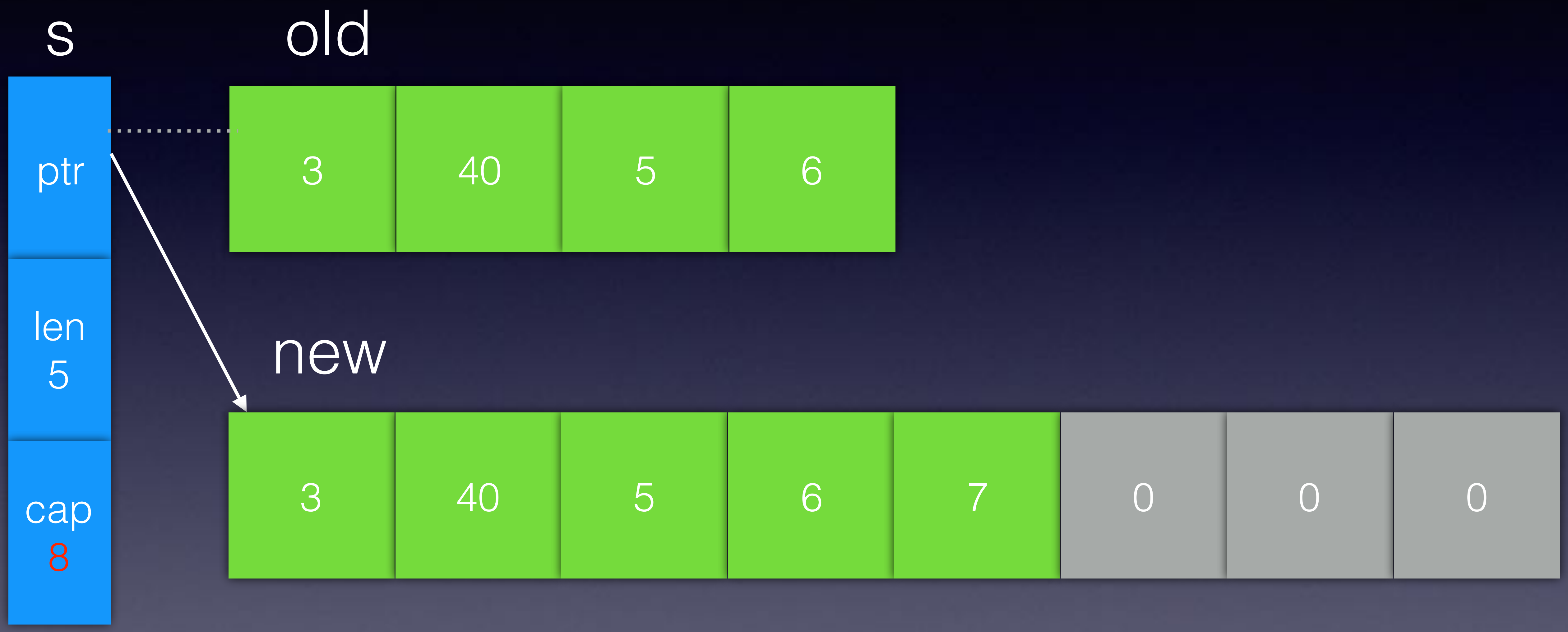
s=append(s, 5)



s=append(s, 6)



s=append(s, 7)



Array Copy

- syntax: copy(destination, source)
  - if length of destination < source, source data will be truncated
- slice1:=[]int{1, 2, 3}
  slice2:=make([]int, 2)
  copy(slice2, slice1) // slice2 = [1,2].

Map

- Declaration
  - var m1 = make(map[string]int
    m1["A"]=1
  - var m2 = map[string]string {
    "007":"James Bond",
    "MissionImpossible":"Ethan",
    "SpiderMan": "Peter Park" }

Nested Map

- var m3 = map[string]map[string]int {
  "John":map[string]int {
  "Math":80,
  "Physics":60 },
  "Mary":map[string]int {
  "Math":90, }
  }

Accessing Map

- Traverse
  - for k,v := range m2 {
    fmt.Printf("key=%v value=%v\n", k, v) }
- Check key and do
  - if val, ok := m2["SpiderMan"]; ok {
    fmt.Printf("SpiderMan also exists: actor=%v\n", val) }

Ch6 Function

Syntax

- func Foo(param1 int, param2 string) int {
    return 1
  }

    - begins with capital case: public (**exported**)

- func foo(param1 int, param2 string) (int, int) {
    return 1, 2
  }

    - begins with lower case: protected (**not exported**)

        - accessible within package

Named Return Data

- ```
  func Foo(param1 int, param2 string) (ret int) {
      ret = 1
      return  // must return, otherwise get compiler error
  }
  ```
  ```

Variadic Functions

- ```
  fun add(args …int) int {
      total:=0
      for k, v := range args {
          total+=v
      }
      return v
  }
  ```
    - args is called a variadic parameter
- variadic parameters must be the last parameter
    - ```
      fun add(int, string, args…int) {
          ….
      }
      add(1, "hello")
      add(1, "hello", 2, 3)
      ```

Closure

- Declare function within a function
- Closure can keep its internal state (state cleared once closure not referenced)
- Closures are passed to other functions by reference
    - passed closure is the original one

```
func main() {
    g1 := MakeNumberGeneratorClosure()
    g2 := MakeNumberGeneratorClosure()
    fmt.Println(g1(),g1(),g2(),g2() )  // 1, 2, 1, 2
    foo(g1)
    fmt.Println(g1())  // 4
}

func MakeNumberGeneratorClosure() func() int {
    i:=0
    return func() int {
        i+=1
        return i
    }
}

func foo(funObj func() int) {  // closure is not copied.
    funObj()
}
```

defer

- deferred function is called after original function completes

- fun main() {
      f, _ := os.Open(filename)
      defer f.Close() // called after leaving main
  }

    - write Open and Close together : easy to understand

    - deferred function are run even if a runtime panic occurs

Pointers

```
func main() {
    x := 0
    foo(&x)
    fmt.Println(x)  // 1
    bar(x)
    fmt.Println(x)  // 1
}

func foo(x *int) { // pointer variable is copied
    *x+=1
}

func bar(x int) {  // value is copied
    x+=1
}
```

new

- get a pointer to a newly allocated memory

- ```
  y:=new(int)
  fmt.Println( *y )  // 0
  ```
  ```

Ch7 Struct and Interfaces

Struct

- type Circle struct {
      x float64
      y flaot64
      r folat64
  }

- type Circle struct {
      x, y, r float64
  }

    - ***type*** keyword creates a new data type

- Initialization

    - c:=Circle{x:0, y:0, r:0 } or c:=Circle {0,0,5}

Struct Method

- func(c* Circle) area() float64 {
    return math.pi * c.r*c.r
  }
    - c* Circle: Receiver
        - So we can use c.area() syntax

Embedded Type(Anonymous Field)

- type Person struct { Name string }
  func (p *Person) Talk() {
  fmt.Println("I am Person, Name is", p.Name) }

- Has a relationship:
  type Android struct {
  Person Person;
  Model string }

- Is-a relationship:
  type Android struct {
  Person
  Model string }

  a:=new(Android)
  a.Person.Talk()
  a.Talk() // Android is Person, so Android can Talk (and Talk can be overridden)

interface

- An interface defines a method set
- An interface is like an pointer to an object
    - However interface cannot access anything of the object except the methods it knows/defines
- An interface is like a "Protocol" or "Contract" when a function wish to receive infinite unknown types but can still work, by calling some common "methods" the unknown types should have (i.e., implement the interface)

Examples

- type Shape interface {
      area() float64
  }

- Implement interface: just have a method of same signature
  type Circle struct {…}
  func(c* Circle) area() float64 {
      ….
  }

Ch8 Packages

Creating Packages

- import golang-book/chapter8/math
    - math = real package name
        - package path is: $GOPATH/src/golang-book/chapter8/math
    - all source files put right in math folder will be scanned for searching "package math"
        - subfolder will not be searched recursively
        - source file name does not matter
    - Best practice: let package name equals the folder name they fall in
    - Data in package source file with capital letter is exposed ; others are only accessible within same package

Package Structure Example & Import

- Assume $GOPATH = ~

- Folder structure:
  ~/src/mylib/sum.go
  ~/src/mylib/mul.go
  ~/src/mylib/sublib/inc.go
  ——————package mylib
  —————————— package sublib

- import mylib
  import mylib/sublib
  x:=mylib.Sum(1,2)
  y:=mylib.Multiply(2,3)
  z:=sublib.Inc(3)

System Packages

- GOROOT determines which version of GO to use
  - Ex. /usr/local/Cellar/go/1.8/libexec
- System packages will be imported and reused (i.e., no need to compile) if they exist
  - Ex. MAC OS example:
    - /usr/local/Cellar/go/1.8/libexec/pkg/darwin_amd64

Import Mechanism Testing

- MacOS system package path: /usr/local/Cellar/go/1.8/libexec/pkg/darwin_amd64
  - By removing system pkg folder, go run still works until it’s slow since all libs should be re-compiled every time
  - By removing /usr/local/Cellar/go/1.8/libexec/src and system pkg, go run will fail
  - By only removing /usr/local/Cellar/go/1.8/libexec/src (system pkg exists), go run still fail
- Conclusion: GO seeks src source first, and then check if system package has corresponding existing library

Ch9 Testing

Run Test

- go test (go test -v: verbose mode): execute all test files under current directory
  - "testing" GO package should be imported
  - test file names should end with _test.go
    - ex. mylib_test.go
  - Function signature should be:
    - ```
      func TestXXXX(t *testing.T) {
          ....
      }
      ```
  - Trigger test error: t.Error(msg1, msg2, msg3 …)
      ```

Ch10 Concurrency

Goroutines

- coroutine that runs concurrently
- fun main() {

```
    go func() {
        fmt.Println("Hello")
    }()  // will not wait goroutine to complete here.
    var input string
    fmt.Scanln(&input)  // to hold the main goroutine
```

Some Example

```
func main() {
    var i = 0
    fmt.Println("main %v Adr=%v", i, &i)
    for i=0;i<5;i++ {
        go func() {
            fmt.Println("main goroutine %v Adr=%v", i, &i)
        }()
    }
    foo()
    var input string
    fmt.Scanln(&input)  // to prevent main from leaving
}

func foo() {
   var i = 0
   fmt.Println("foo %v Adr=%v", i, &i)
    for i=0;i<5;i++ {
        go func() {
            fmt.Println("foo goroutine %v Ard=%v", i, &i)  // note: they will not print what you may be thinking
!
        }()
    }
}
```

About Stack/Heap Data Allocation

- The goroutine in previous example can refer to local variable in foo, even after foo exits
- The GO compiler will infer whether to allocate data in stack or heap
  - If compiler cannot determine a data won't be referenced after function leave, it will allocate it on heap. Otherwise, it prefers to allocate on stack for better performance
    - See GO FAQ: https://golang.org/doc/faq#stack_or_heap

Goroutines Race Condition

```
func UnSafe() {
    var wg sync.WaitGroup
    var counter int = 0
    for i:=0; i<1000; i++ {
        wg.Add(1)
        go Foo1(&wg, &counter)
    }
    wg.Wait()
    fmt.Println("UnSafe:counter=", counter)  // will not equal 10000000
}
func Foo1(wg *sync.WaitGroup, counter *int) {  // race conditon !
    defer wg.Done()
    for i:=0; i<10000; i++ {
        add(counter)
    }
}
func add(i *int) {
    *i+=1
}
```

GO Slogan:

Don't communicate by shared memory. Share memory by communicating

However some experiment shows that channels are less efficient than Mutex. When using channels, you are still using a lock wrapped by channel

- So for those frequently accessed shared memory, Mutex is still an option.
- For architectural factor that is less frequently accessed, channels may be considered
- Channel size is fixed at declaration, while you can have growable built-in data structure by using mutex

Channels

- Channels are reference types
  - Other reference types: slice, map, pointers, function
  - Reference type: only the data structure referring to source memory is copied; referred memory is not copied
  - So you can pass a channel to multi functions without using &
    - ```
      var c chan string = make(chan string)
      fun1(c)
      fun2(c) // fun1 and fun2 receive the same channel instance, not copied separate instances
      ```
      ```

Channels

- Channels are synchronized by default
  - send / receive blocks, until both ends are ready
    - The first grouting to take action is blocked; the second one will free the blocking goroutine on the other side, and the second grouting is able to keep going without blocking
- Non-blocking channel operation:
  - select {
    case ch<-1: … ch1 has data
    default: … // ch1 has no data
    }

UnBlocked Channel Select

- ```
  select {
    case msg1 := ch<-1: …
    default: … // triggers immediately if ch1 has no data
  }
  ```
  ```

Channel Direction

- restrict a channel to be either sending or reading channels
  - read only: func pinger(c chan<- string) {…}
  - send only: func longer(c <-chan string) {…}

Buffered Channels

- Asynchronous channel:
  - c:= make(chan int, 100) // channel with buffer size 100
- Default channel is synchronous (buffer size = 0)
  - make(chan int) == make(chan int, 0)