Seminario de Lenguajes opción Go

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Seminario de Lenguajes opción Go

- Concurrencia
- Goroutines
- WaitGroup
- Channels
- Select
- Monitores
- Semáforos

Concurrencia

- Concurrencia
- Paralelismo
- Threads / Task / Process
- Goroutine: función que es capaz de ejecutar concurrentemente con otras funciones

Concurrencia - Goroutines

```go
func f(n int) {
  for i := 0; i < 10; i++ {
    fmt.Println(n, ":", i)
  }
}

func main() {
  go f(0)
  fmt.Scanln()
}
```

```
0 : 0
0 : 1
0 : 2
0 : 3
0 : 4
0 : 5
0 : 6
0 : 7
0 : 8
0 : 9
```

Concurrencia - Goroutines

```go
func f(n int) {
  for i := 0; i < 10; i++ {
    fmt.Println(n, ":", i)
  }
}

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

```
2 : 0    3 : 0    8 : 3    5 : 8    9 : 0
2 : 1    3 : 1    8 : 4    5 : 9    9 : 1
2 : 2    3 : 2    8 : 5    4 : 2    9 : 2
2 : 3    3 : 3    8 : 6    4 : 3    9 : 3
2 : 4    3 : 4    8 : 7    4 : 4    9 : 4
2 : 5    3 : 5    8 : 8    4 : 5    9 : 5
2 : 6    3 : 6    8 : 9    4 : 6    9 : 6
2 : 7    3 : 7    6 : 5    4 : 7    9 : 7
2 : 8    3 : 8    6 : 6    4 : 8    9 : 8
2 : 9    3 : 9    6 : 7    4 : 9    9 : 9
0 : 0    6 : 0    6 : 8    1 : 0    7 : 0
0 : 1    6 : 1    6 : 9    1 : 1    7 : 1
0 : 2    6 : 2    5 : 0    1 : 2    7 : 2
0 : 3    6 : 3    5 : 1    1 : 3    7 : 3
0 : 4    6 : 4    5 : 2    1 : 4    7 : 4
0 : 5    4 : 0    5 : 3    1 : 5    7 : 5
0 : 6    4 : 1    5 : 4    1 : 6    7 : 6
0 : 7    8 : 0    5 : 5    1 : 7    7 : 7
0 : 8    8 : 1    5 : 6    1 : 8    7 : 8
0 : 9    8 : 2    5 : 7    1 : 9    7 : 9
```

Concurrencia - Goroutines

```go
import ("fmt"; "math/rand"; "time")

func f(n int) {
  for i := 0; i < 10; i++ {
    fmt.Println(n, ":", i)
    amt := time.Duration(rand.Intn(250))
    time.Sleep(time.Millisecond * amt)
  }
}

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

```
| 2 : 0   | 3 : 2   | 1 : 2   | 5 : 6   | 4 : 6
| 1 : 0   | 9 : 2   | 0 : 3   | 3 : 6   | 7 : 9
| 0 : 0   | 0 : 1   | 8 : 3   | 6 : 7   | 8 : 8
| 6 : 0   | 6 : 2   | 1 : 3   | 4 : 5   | 9 : 6
| 4 : 0   | 5 : 2   | 7 : 4   | 8 : 5   | 0 : 6
| 8 : 0   | 3 : 3   | 2 : 4   | 9 : 5   | 3 : 9
| 7 : 0   | 5 : 3   | 4 : 4   | 0 : 5   | 5 : 8
| 9 : 0   | 5 : 4   | 1 : 4   | 7 : 7   | 5 : 9
| 5 : 0   | 4 : 2   | 3 : 5   | 3 : 7   | 9 : 7
| 3 : 0   | 0 : 2   | 5 : 5   | 2 : 8   | 1 : 8
| 5 : 1   | 4 : 3   | 2 : 5   | 8 : 6   | 4 : 7
| 3 : 1   | 7 : 2   | 6 : 6   | 1 : 6   | 0 : 7
| 7 : 1   | 3 : 4   | 8 : 4   | 3 : 8   | 4 : 8
| 6 : 1   | 6 : 3   | 1 : 5   | 6 : 8   | 8 : 9
| 9 : 1   | 6 : 4   | 2 : 6   | 5 : 7   | 4 : 9
| 4 : 1   | 8 : 2   | 7 : 5   | 8 : 7   | 1 : 9
| 2 : 1   | 7 : 3   | 0 : 4   | 6 : 9   | 9 : 8
| 8 : 1   | 6 : 5   | 7 : 6   | 1 : 7   | 0 : 8
| 1 : 1   | 9 : 3   | 2 : 7   | 7 : 8   | 9 : 9
| 2 : 2   | 2 : 3   | 9 : 4   | 2 : 9   | 0 : 9
```

Concurrencia - Goroutines

```go
func responseSize(url string) {
  fmt.Println("Getting ", url)
  response, err := http.Get(url)
  if err != nil {
    log.Fatal(err)
  }

  defer response.Body.Close()

  body, err := io.ReadAll(response.Body)
  if err != nil {
    log.Fatal(err)
  }
  fmt.Println(url, len(body))
}
```

```go
package main

import (
  "fmt"
  "io"
  "log"
  "net/http"
)

func main() {
  go responseSize("https://www.golangprograms.com")
  go responseSize("https://coderwall.com")
  go responseSize("https://stackoverflow.com")
  go responseSize("https://web.arba.gov.ar")
  fmt.Scanln()
}
```

```
Getting  https://coderwall.com
Getting  https://stackoverflow.com
Getting  https://www.golangprograms.com
Getting  https://www.info.unlp.edu.ar
https://www.info.unlp.edu.ar 184387
https://stackoverflow.com 173099
https://www.golangprograms.com 32693
https://coderwall.com 185287
```

Concurrencia - Goroutines

```go
package main

import (
  "fmt"
  "io"
  "log"
  "net/http"
)

var urls = []string{
  "https://www.golangprograms.com",
  "https://coderwall.com",
  "https://stackoverflow.com",
  "https://www.info.unlp.edu.ar",
}

func main() {
  for _, url := range urls {
    go responseSize(url)
  }
  fmt.Scanln()
}
```

```go
func responseSize(url string) {
  fmt.Println("Getting ", url)
  response, err := http.Get(url)
  if err != nil {
    log.Fatal(err)
  }

  defer response.Body.Close()

  body, err := io.ReadAll(response.Body)
  if err != nil {
    log.Fatal(err)
  }
  fmt.Println(url, len(body))
}
```

```
Getting  https://coderwall.com
Getting  https://stackoverflow.com
Getting  https://www.golangprograms.com
Getting  https://www.info.unlp.edu.ar
https://www.info.unlp.edu.ar 184387
https://stackoverflow.com 173099
https://www.golangprograms.com 32693
https://coderwall.com 185287
```

Concurrencia - WaitGroup

- WaitGroup
  - Permite que una goroutine espere la terminación de otras goroutines
  - El tipo `sync.WaitGroup` se puede pensar como un contador
  - El tipo `sync.WaitGroup` define los métodos:
    - `Add(delta int)`: incrementa (o decrementa) el contador
    - `Done()`: decrementa en 1 el contador
    - `Wait()`: bloquea a la goroutine que la ejecuta hasta que el contador llegue a cero

Concurrencia - WaitGroup

```go
import (
  "fmt"
  "io"
  "log"
  "net/http"
  "sync"
)

var wg sync.WaitGroup

var urls = []string{
  "https://www.golangprograms.com",
  "https://coderwall.com",
  "https://stackoverflow.com",
  "https://www.info.unlp.edu.ar",
}

func main() {
  for _, url := range urls {
    wg.Add(1)
    go responseSize(url)
  }
  wg.Wait()
}
```

```go
func responseSize(url string) {
  defer wg.Done()

  fmt.Println("Getting ", url)
  response, err := http.Get(url)
  if err != nil {
    log.Fatal(err)
  }

  defer response.Body.Close()

  body, err := io.ReadAll(response.Body)
  if err != nil {
    log.Fatal(err)
  }
  fmt.Println(url, len(body))
}
```

```
Getting  https://coderwall.com
Getting  https://stackoverflow.com
Getting  https://www.golangprograms.com
Getting  https://www.info.unlp.edu.ar
https://www.info.unlp.edu.ar 184387
https://stackoverflow.com 173099
https://www.golangprograms.com 32693
https://coderwall.com 185287
```

Concurrencia - WaitGroup

```go
import (
  ...
)

~~var wg sync.WaitGroup~~

var urls = []string{
  ...
}

func main() {
  var wg sync.WaitGroup

  for _, url := range urls {
    wg.Add(1)
    go func(url string) {
      defer wg.Done()
      responseSize(url)
    }(url)
  }
  wg.Wait()
}
```

```go
func responseSize(url string) {
  ~~defer wg.Done()~~

  fmt.Println("Getting ", url)
  response, err := http.Get(url)
  if err != nil {
    log.Fatal(err)
  }

  defer response.Body.Close()

  body, err := io.ReadAll(response.Body)
  if err != nil {
    log.Fatal(err)
  }
  fmt.Println(url, len(body))
}
```

```
Getting  https://coderwall.com
Getting  https://stackoverflow.com
Getting  https://www.golangprograms.com
Getting  https://www.info.unlp.edu.ar
https://www.info.unlp.edu.ar 184387
https://stackoverflow.com 173099
https://www.golangprograms.com 32693
https://coderwall.com 185287
```

Concurrencia - Channels

- Channels
  - Mecanismo que permite que las goroutines se comuniquen y se sincronicen
  - Conducto “tipado” a través del cual una goroutine envía datos a otra
  - Por defecto, tanto la acción de enviar como la recibir bloquean a la goroutine que la ejecuta hasta que la del “otro extremo” esté lista.

Concurrencia - Channels

- Se declaran antes de usarlos

```
msg := make(chan string) | var msg chan string = make(chan string)
nums := make(chan int)   | var nums chan int = make(chan int)
```

- El “zero value” de un channer es `nil`

```
     var nums chan int // nil
```

- Send

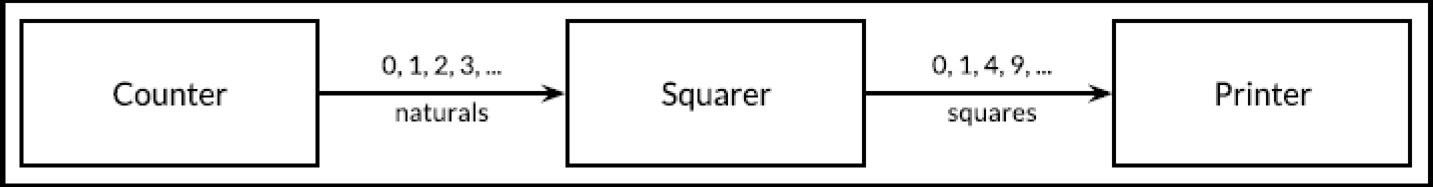
```
     nums <- x
```

- Receive

```
     x = <-nums
     <-nums
```

Concurrencia - Channels

- Ejemplo



```
func main() {
  naturals := make(chan int)
  squares := make(chan int)

  // Counter
  go func() {
    for x := 0; ; x++ {
      naturals <- x
    }
  }()
```

```
  // Squarer
  go func() {
    for {
      x := <-naturals
      squares <- x * x
    }
  }()

  // Printer
  for {
    fmt.Println(<-squares)
  }
}
```

```
0
1
4
9
16
25
36
49
64
81
100
121
144
...
```

Concurrencia - Channels

- Se pueden cerrar

```
close(nums)
```

- El receptor …

```
x, ok := <-nums
```

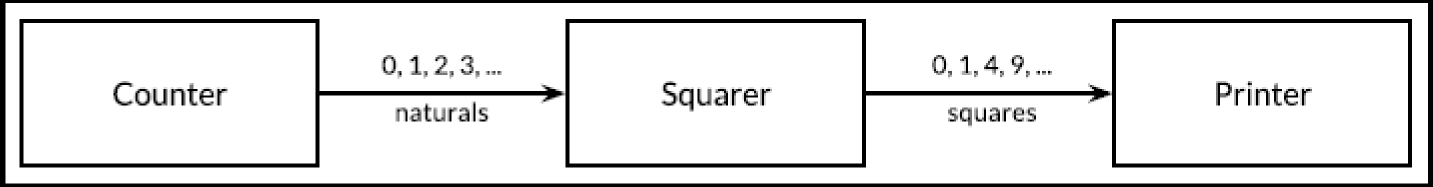
  si `ok` es `false` el channel no tiene más valores y está cerrado

- Range
  - Recibe valores repetidamente hasta que eventualmente el channel (`nums`) es cerrado

```
for x := range nums {
  fmt.Println(i)
}
```

Concurrencia - Channels

- Ejemplo



```
func main() {
  naturals := make(chan int)
  squares := make(chan int)

  // Counter
  go func() {
    for x := 0; x < 10; x++ {
      naturals <- x
    }
    close(naturals)
  }()
```

```
  // Squarer
  go func() {
    for x := range naturals {
      squares <- x * x
    }
    close(squares)
  }()

  // Printer
  for x := range squares {
    fmt.Println(x)
  }
}
```

```
0
1
4
9
16
25
36
49
64
81
```

Concurrencia - Channels

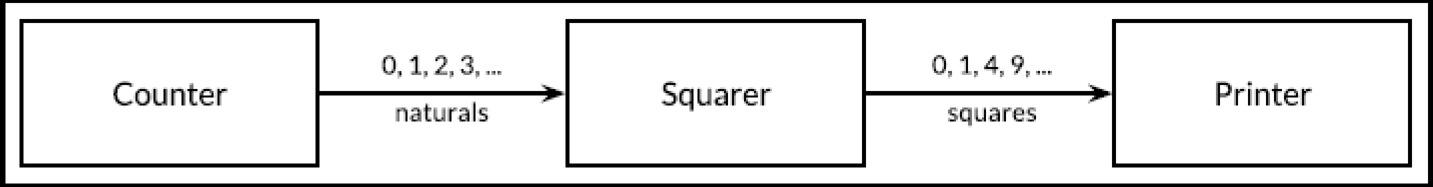
- Pueden ser "unidireccionales"
  - Send-only channel

    ```
    chan<- int
    ```
  - Receive-only channel

    ```
    <-chan int
    ```
- Sólo la goroutine "sender" puede cerrar un send-only channel
- Intentar cerrar un receive-only channel produce en error en tiempo de compilación

Concurrencia - Channels

- Ejemplo



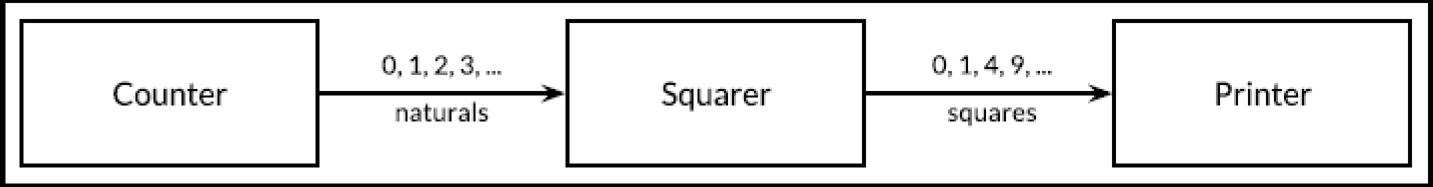
```go
func main() {
  naturals := make(chan int)
  squares := make(chan int)

  // Counter
  go func(out chan<- int) {
    for x := 0; x < 10; x++ {
      out <- x
    }
    close(out)
  }(naturals)
```

```go
  // Squarer
  go func(in <-chan int, out chan<- int) {
    for x := range in {
      out <- x * x
    }
    close(out)
  }(naturals, squares)

  // Printer
  for x := range squares {
    fmt.Println(x)
  }
}
```

```
0
1
4
9
16
25
36
49
64
81
```

Concurrencia - Channels

- Ejemplo



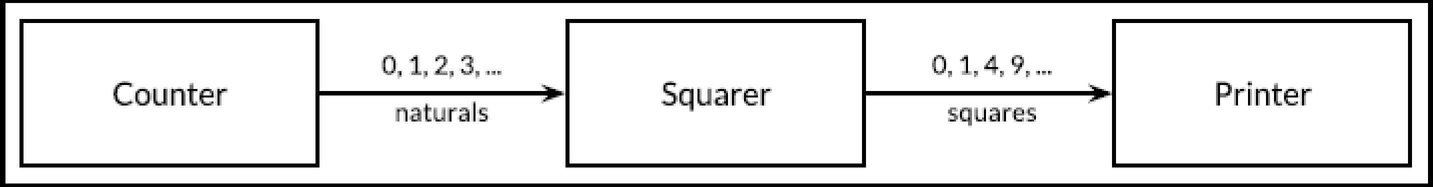
```go
func counter(out chan<- int) {
  for x := 0; x < 10; x++ {
    out <- x
  }
  close(out)
}

func squarer(in <-chan int, out chan<- int) {
  for x := range in {
    out <- x * x
  }
  close(out)
}
```

```go
func printer(in <-chan int) {
  for x := range in {
    fmt.Println(x)
  }
}

func main() {
  naturals := make(chan int)
  squares := make(chan int)

  go counter(naturals)
  go squarer(naturals, squares)
  printer(squares)
}
```

```
0
1
4
9
16
25
36
49
64
81
```

Concurrencia - Channels

- Ejemplo



```
func counter(out chan<- int) {
  for x := 0; x < 10; x++ {
    out <- x
  }
  close(out)
}

func squarer(in <-chan int, out chan<- int) {
  for x := range in {
    out <- x * x
  }
  close(out)
}
```

unidireccional

```
func printer(in <-chan int) {
  for x := range in {
    fmt.Println(x)
  }
}

func main() {
  naturals := make(chan int)
  squares := make(chan int)

  go counter(naturals)
  go squarer(naturals, squares)
  printer(squares)
}
```

unidireccional

bidireccional

```
0
9
16
25
36
49
64
81
```

Concurrencia - Buffered channels

- Buffered channels

```
ch = make(chan string, 3)
```

- Tiene asociada una cola de elementos con la capacidad definida en la declaración
- Un “send” agrega un elemento al final de la cola y un “receive” quita y devuelve un elemento del inicio

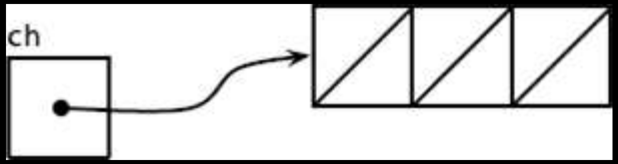
Concurrencia – Buffered channels

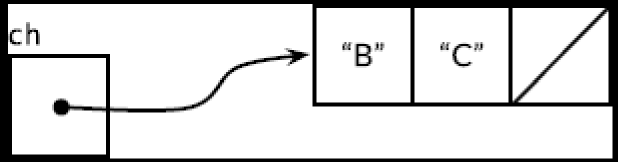
```
ch <- "A"
ch <- "B"
ch <- "C"
```

```
fmt.Println(<-ch) // "A"
```

```
fmt.Println(cap(ch)) // "3"
```

```
fmt.Println(len(ch)) // "2"
```





Concurrencia - Buffered channels

- Productor / Consumidor
  - Un productor genera datos que pone en un buffer
  - Un consumidor saca datos del buffer y los consume

```go
func Producer(out chan<- int) {
  timeProducer := rand.Intn(250)
  totalProduce := 10
  for i := 0; i < totalProduce; i++ {
    time.Sleep(time.Millisecond *
                time.Duration(timeProducer))
    product := rand.Intn(1000)
    out <- product
  }
}
```

```go
func Consumer(in <-chan int) {
  timeConsumer := rand.Intn(1000)
  for i := range in {
    time.Sleep(time.Millisecond *
                time.Duration(timeConsumer))
  }
}
```

prod_cons.go

```go
func main() {
  ch := make(chan int, 5)

  var wgC sync.WaitGroup
  wgC.Add(1)

  go func() {
    Producer(ch)
    close(ch)
  }()

  go func() {
    Consumer(ch)
    wgC.Done()
  }()

  wgC.Wait()
}
```

Concurrencia - Buffered channels

- Productores / Consumidores

```go
func Producer(out chan<- int) {
  timeProducer := rand.Intn(250)
  totalProduce := 10
  for i := 0; i < totalProduce; i++ {
    time.Sleep(time.Millisecond *
               time.Duration(timeProducer))
    product := rand.Intn(1000)
    out <- product
  }
}
```

```go
func Consumer(in <-chan int) {
  timeConsumer := rand.Intn(1000)
  for i := range in {
    time.Sleep(time.Millisecond *
               time.Duration(timeConsumer))
  }
}
```

```go
func main() {
  ch := make(chan int)
  cProd := 2
  cCons := 5

  var wgP, wgC sync.WaitGroup

  wgP.Add(cProd)
  wgC.Add(cCons)
```

prod_cons_1.go

```go
  for c := 1; c <= cCons; c++ {
    go func(id int) {
      Consumer(id, ch)
      wgC.Done()
    }(c)
  }

  for p := 1; p <= cProd; p++ {
    go func(id int) {
      Producer(id, ch)
      wgP.Done()
    }(p)
  }

  wgP.Wait()
  close(ch)
  wgC.Wait()
}
```

Concurrencia - Buffered channels

- Mirrored request

```
func mirroredQuery() string {
  responses := make(chan string, 3)

  go func() {
    responses <- request("asia.google.com")
  }()

  go func() {
    responses <- request("europe.google.com")
  }()

  go func() {
    responses <- request("americas.google.com")
  }()

  return <-responses // return the quickest response
}

func request(hostname string) (response string)
{ /* ... */ }
```

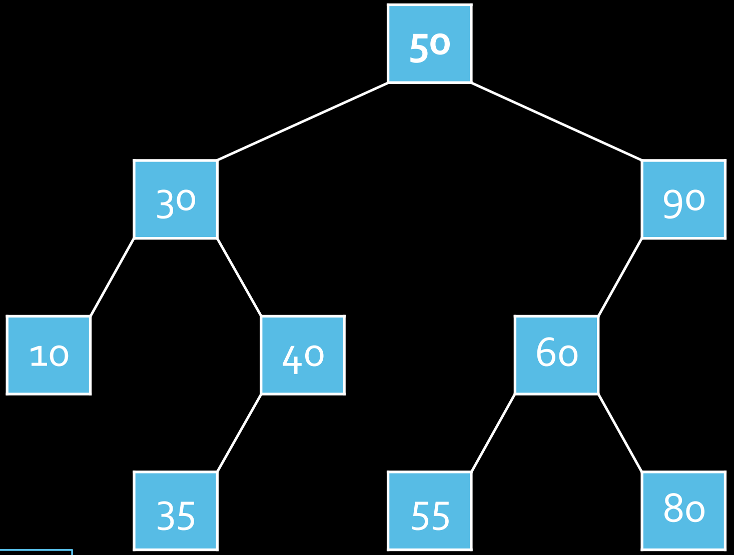
Qué pasaría con un unbuffered channel?

```
func mirroredQuery() string {
  responses := make(chan string)

  go func() {
    responses <- request("asia.google.com")
  }()

  go func() {
    responses <- request("europe.google.com")
  }()

  go func() {
    responses <- request("americas.google.com")
  }()

  return <-responses
}
```

Concurrencia – Concurrencia recursiva

```go
func lt(x, y int) bool {
  return x <= y
}

func main() {
  var t *tree.Tree[int]
  for _, i := range []int{50, 30, 90, 40, 60, 10, 80, 35, 55} {
    t = t.Insert(i, lt)
  }
  fmt.Println("Tree:", t.GetAll())

  allPaths := t.AllPaths()
  for _, path := range allPaths {
    fmt.Println(path)
  }
}
```

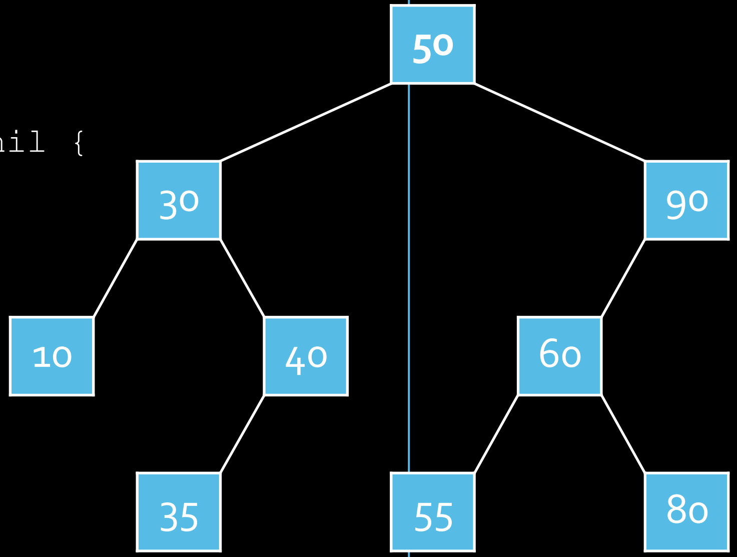
```
Tree: [10 30 35 40 50 55 60 80 90]
Paths:
[50 90]
[50 90 60 80]
[50 90 60 55]
[50 30 40]
[50 30 40 35]
[50 30 10]
```



Concurrencia – Concurrencia recursiva

```go
func (t *Tree[T]) AllPaths() [][]T {
  var paths [][]T
  ch := make(chan []T)

  var wg sync.WaitGroup
  wg.Add(2)

  go func(in <-chan []T) {
    for path := range in {
      paths = append(paths, path)
    }
    wg.Done()
  }(ch)

  go func(ch chan []T) {
    t.finder([]T{}, ch)
    close(ch)
    wg.Done()
  }(ch)

  wg.Wait()
  return paths
}
```

```go
func (t *Tree[T]) finder(path []T, out chan<- []T) {
  if t == nil { return }

  path = append(path, t.val)

  if t.left == nil || t.right == nil {
    out <- path
  }

  var wgf sync.WaitGroup

  if t.left != nil {
    wgf.Add(1)
    go func() {
      t.left.finder(path, out)
      wgf.Done()
    }()
  }
  if t.right != nil {
    wgf.Add(1)
    go func() {
      t.right.finder(path, out)
      wgf.Done()
    }()
  }

  wgf.Wait()
}
```



Concurrencia - Select

- `Select` permite que una goroutine espere por más de un channels
  - Send o receive

```
ch1 := make(chan int)
ch2 := make(chan int)

go func() {
  for i := 1; i <= 10; i++ {
    ch1 <- i
  }
  close(ch1)
}()

go func() {
  for i := 1; i <= 10; i++ {
    ch2 <- i
  }
  close(ch2)
}()
```

```
var val int
ok1 := true
ok2 := true
for ok1 && ok2 {
  select {
  case val, ok1 = <-ch1:
    if ok1 {
      prnt("ch1", val)
    }
  case val, ok2 = <-ch2:
    if ok2 {
      prnt("ch2", val)
    }
  }
}
```

```
func prnt(ch string, val int) {
  fmt.Printf("Received from %v: %v", ch, val)
}
```

```
if !ok2 {
  for val = range ch1 {
    prnt("ch1", val)
  }
}
if !ok1 {
  for val = range ch2 {
    prnt("ch2", val)
  }
}
```

select2.go

Concurrencia - Select

- Problema de los fumadores
  - 3 fumadores alrededor de una mesa
  - Para fumar un cigarrillo se precisa tabaco, papel y fósforo
  - Cada fumador tiene una cantidad ilimitada de un ingrediente
    - Sandy tiene papeles
    - Apple tiene tabaco
    - Daisy tiene fósforos
  - Un "dealer" tiene cantidades ilimitadas de todos los ingredientes
  - El dealer elige al azar un fumador y pone sobre la mesa los dos ingredientes que a dicho fumador le falta
  - El fumador elegido toma los elementos de la mesa, arma su cigarrillo y lo fuma

Concurrencia - Select

- Problema de los fumadores

```
const (
  paper = iota
  grass
  match
)

var smokers = map[int]string{
  paper: "Sandy",
  grass: "Apple",
  match: "Daisy",
}

var wg sync.WaitGroup
```

```
func main() {
  var ingredients [3]chan int
  var signals [3]chan int

  wg.Add(4)
  for i := range smokers {
    ingredients[i] = make(chan int)
    signals[i] = make(chan int)
  }

  for i := range smokers {
    go smoker(i, signals, ingredients)
  }
  go arbitrate(signals, ingredients)
  wg.Wait()
}
```

smokers.go

Concurrencia - Select

- Problema de los fumadores

```
func arbitrate(signals, ingredients [3]chan int) {
  for i := 0; i < 10; i++ {
    time.Sleep(time.Millisecond * 500)
    next := rand.Intn(3)
    fmt.Println("\nNext:", smokers[next])
    signals[next] <- next
    for c := range ingredients {
      if c != next {
        ingredients[c] <- 1
      }
    }
  }
  for c := range signals {
    close(signals[c])
  }
  wg.Done()
}
```

```
func smoker(id int, signals, ingredients [3]chan int) {
  count := 0
  for range signals[id] {
    select {
    case <-ingredients[paper]:
    case <-ingredients[grass]:
    case <-ingredients[match]:
    }
    time.Sleep(10 * time.Millisecond)
    select {
    case <-ingredients[paper]:
    case <-ingredients[grass]:
    case <-ingredients[match]:
    }
    time.Sleep(time.Millisecond * 500)
    count++
    fmt.Printf("%v%s smokes %v cigarettes\n",
      strings.Repeat("\t", 3+6*id),
      smokers[id],
      count)
  }
  wg.Done()
}
```

Concurrencia - Select

- Problema de los fumadores

```
for i := 0; i < 2; i++ {
  select {
  case <-ingredients[paper]:
  case <-ingredients[grass]:
  case <-ingredients[match]:
  }
  time.Sleep(10 * time.Millisecond)
}
```

```
for range signals[id] {
  for i := range ingredients {
    if i != id {
      <-ingredients[i]
    }
  }
```

```
func smoker(id int, signals, ingredients [3]chan int) {
  count := 0
  for range signals[id] {
    select {
    case <-ingredients[paper]:
    case <-ingredients[grass]:
    case <-ingredients[match]:
    }
    select {
    case <-ingredients[paper]:
    case <-ingredients[grass]:
    case <-ingredients[match]:
    }
    time.Sleep(time.Millisecond * 500)
    count++
    fmt.Printf("%v%s smokes %v cigarettes\n",
      strings.Repeat("\t", 3+6*id),
      smokers[id],
      count)
  }
  wg.Done()
}
```

Concurrencia - Select

- Problema de los fumadores

```go
func arbitrate(signals, ingredients [3]chan int) {
  for i := 0; i < 10; i++ {
    time.Sleep(time.Millisecond * 500)
    next := rand.Intn(3)
    fmt.Println("\nNext:", smokers[next])
    signals[next] <- next
    for c := range ingredients {
      if c != next {
        ingredients[c] <- 1
      }
    }
  }
  for c := range signals {
    close(signals[c])
  }
  wg.Done()
}
```

```go
select {
case ingredients[paper] <- 1:
case ingredients[grass] <- 1:
case ingredients[match] <- 1:
}
select {
case ingredients[paper] <- 1:
case ingredients[grass] <- 1:
case ingredients[match] <- 1:
}
```

```go
for j := 0; j < 2; j++ {
  select {
  case ingredients[paper] <- 1:
  case ingredients[grass] <- 1:
  case ingredients[match] <- 1:
  }
}
```

Concurrencia – Select condicional

- `Select` puede utilizar una alternativa "`default`" para send o receive sin bloqueo.

```go
ch1 := make(chan int)
ch2 := make(chan int)

go func() {
  for i := 0; i < 10; i++ {
    ch1 <- 1
  }
  ch1 <- 0
}()

go func() {
  for i := 0; i < 10; i++ {
    ch2 <- 2
  }
  ch2 <- 0
}()
```

```go
fin := 0
for fin < 2 {
  select {
  case val := <-ch1:
    if val == 0 {
      fin++
    }
  case val := <-ch2:
    if val == 0 {
      fin++
    }
  default:
    // do something
  }
}
```

select3.go

Concurrencia – Select condicional

```go
ch1 := make(chan int)
ch2 := make(chan int)
var wg sync.WaitGroup
wg.Add(2)

go func() {
  var val int
  for val != 100 {
    val := <-ch1
  }
  wg.Done()
}()

go func() {
  var val int
  for val != 100 {
    val := <-ch2
  }
  wg.Done()
}()
```

```go
for i := 0; i < 20; i++ {
  select {
  case ch1 <- i:
  case ch2 <- i:
  default:
    // do something
  }
}
ch1 <- 0
ch2 <- 0
wg.Wait()
```

select4.go

```
                          Received from ch2: 2
Received from ch1: 1
Received from ch1: 4
                          Received from ch2: 6
Received from ch1: 8
                          Received from ch2: 10
Received from ch1: 12
                          Received from ch2: 14
Received from ch1: 15
                          Received from ch2: 19
Received from ch1: 18
Received from ch1: 0
                          Received from ch2: 0
```

Concurrencia – Exclusión mutua

- Problema de la exclusión mutua

```go
var balance int

func Deposit(amount int) {
  balance = balance + amount
}

func Balance() int {
  return balance
}

func main() {
  for i := 0; i < 10; i++ {
    Deposit(100)
  }
  fmt.Println(Balance())
}
```

```
1000
```

```go
var balance int

func Deposit(amount int) {
  balance = balance + amount
}

func Balance() int {
  return balance
}

func main() {
  for i := 0; i < 10; i++ {
    go Deposit(100)
  }
  fmt.Println(Balance())
}
```

```
900
600
800
```

bank.go

Concurrencia – Exclusión mutua

- Problema de la exclusión mutua - Monitores

```go
package bankMonitor

import "fmt"

var deposits = make(chan int)
var balances = make(chan int)

func Deposit(amount int) {
  deposits <- amount
}

func Balance() int {
  return <-balances
}
```

```go
func teller() {
  var balance int
  for {
    select {
    case amount := <-deposits:
      balance += amount
      fmt.Println("balance:", balance)
    case balances <- balance:
    }
  }
}

func init() {
  go teller()
}
```

bankMonitor.go

```go
package main

import (
  "fmt"
  bm "mutex/bankMonitor"
  "sync"
)

func main() {
  var wg sync.WaitGroup
  wg.Add(10)
  for i := 0; i < 10; i++ {
    go func() {
      bm.Deposit(100)
      wg.Done()
    }()
  }
  wg.Wait()
  fmt.Println(bm.Balance())
}
```

bank2.go

Concurrencia – Exclusión mutua

- Semáforo binario
- Type `Mutex`
- Methods:
  - `func (m *Mutex) Lock()`
    - Bloquea `m`
    - Si `m` ya está bloqueado, la goroutine que invoca a `Lock` se bloquea hasta que otra goroutine invoque a `Unlock`
  - `func (*Mutex) Unlock`
    - Desbloquea `m`
    - Si `m` no está bloqueado se produce un error en tiempo de ejecución

Concurrencia – Exclusión mutua

- Semáforo binario

```go
import "sync"

var (
  mu sync.Mutex
  balance int
)

func Deposit(amount int) {
  mu.Lock()
  balance = balance + amount
  mu.Unlock()
}

func Balance() int {
  mu.Lock()
  b := balance
  mu.Unlock()
  return b
}
```

bankSem.go

Variables resguardadas

Sección crítica

Sección crítica

```go
mu.Lock()
defer mu.Unlock()
return balance
```

```go
package main

import (
  "fmt"
  bs "mutex/bankSem"
  "sync"
)

func main() {
  var wg sync.WaitGroup
  wg.Add(10)
  for i := 0; i < 10; i++ {
    go func() {
      bs.Deposit(100)
      wg.Done()
    }()
  }
  wg.Wait()
  fmt.Println(bs.Balance())
}
```

bank3.go

Concurrencia – Exclusión mutua

- Semáforo binario

```
func Withdraw(amount int) bool {
  Deposit(-amount)
  if Balance() < 0 {
    Deposit(amount)
    return false // insufficient funds
  }
  return true
}
```

No atómico

Concurrencia – Exclusión mutua

- Semáforo binario

```go
func Withdraw(amount int) bool {
  Deposit(-amount)
  if Balance() < 0 {
    Deposit(amount)
    return false // insufficient funds
  }
  return true
}
```

No atómico

```go
var (
  mu sync.Mutex
  balance int
)
...
func Deposit(amount int) {
  mu.Lock()
  balance = balance + amount
  mu.Unlock()
}

func Withdraw(amount int) bool {
  mu.Lock()
  defer mu.Unlock()
  Deposit(-amount)
  if Balance() < 0 {
    Deposit(amount)
    return false
  }
  return true
}
```

Deadlock

Concurrencia – Exclusión mutua

- Semáforo binario

```go
var (
  mu      sync.Mutex
  balance int
)

func Deposit(amount int) {
  mu.Lock()
  defer mu.Unlock()
  deposit(amount)
}

func deposit(amount int) {
  balance += amount
}
```

bankSem2.go

```go
func Balance() int {
  mu.Lock()
  defer mu.Unlock()
  return balance
}

func Withdraw(amount int) bool {
  mu.Lock()
  defer mu.Unlock()
  deposit(-amount)
  if balance < 0 {
    deposit(amount)
    return false  }
  return true
}
```

```go
func main() {
  var wg sync.WaitGroup
  wg.Add(15)
  for i := 0; i < 10; i++ {
    go func() {
      bs.Deposit(100)
      wg.Done()
    }()
  }
  for i := 0; i < 5; i++ {
    go func() {
      bs.Withdraw(100)
      wg.Done()
    }()
  }
  wg.Wait()
  fmt.Println(bs.Balance())
}
```

bank4.go

Concurrencia – Exclusión mutua

- Semáforo "un escritor – múltiples lectores"
- Type `RWMutex`
- Methods:
  - `func (rw *RWMutex) Lock()`
    - Bloquea `rw` para escritura
    - Si `rw` ya está bloqueado para lectura o escritura, la goroutine que invoca a `Lock` se bloquea hasta que otra goroutine invoque a `Unlock` o `RUnlock` según corresponda
  - `func (rw *RWMutex) Unlock()`
    - Desbloquea `rw` para escritura
    - Si `rw` no está bloqueado para escritura se produce un error en tiempo de ejecución
  - `func (rw *RWMutex) RLock()`
    - Bloquea `rw` para lectura
    - Si `rw` ya está bloqueado para escritura, la goroutine que invoca a `RLock` se bloquea hasta que otra goroutine invoque a `Unlock`
  - `func (rw *RWMutex) RUnlock()`
    - Desbloquea `rw` para lectura
    - Si `rw` no está bloqueado para lectura se produce un error en tiempo de ejecución

Concurrencia – Exclusión mutua

- Semáforo "un escritor – múltiples lectores"

```go
var (
  mu      sync.Mutex
  balance int
)

func Deposit(amount int) {
  mu.Lock()
  defer mu.Unlock()
  deposit(amount)
}

func deposit(amount int) {
  balance += amount
}
```

bankSem3.go

```go
func Balance() int {
  mu.RLock()
  defer mu.RUnlock()
  return balance
}

func Withdraw(amount int) bool {
  mu.Lock()
  defer mu.Unlock()
  deposit(-amount)
  if balance < 0 {
    deposit(amount)
    return false  }
  return true
}
```