A Whirlwind Tour of Go

Just the Cool Parts

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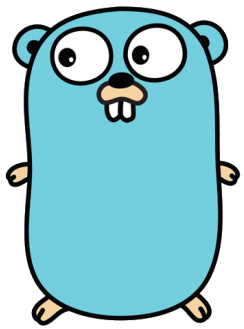
v1.1.0



The Point

- "What *is* Go?"
- "What is it actually good for?"
- "Why should I care?"

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  - ... but cleaned up and streamlined a bit.
- Dreamed up while waiting on a 45-minute C++ compile
  - Fast compilation
  - Native binary compiler with low overhead
  - Strong static typing
  - Extraordinarily spartan

The Basics

This is the “whirlwind” part...

(Laying a foundation of the basics so the more interesting discussions are understandable.)

Intrinsic Data Types

- The usual suspects: `int`, `int8`, `int16`, `int32`, `int64`, `uint`, `uint8`, `uint16`, `uint32`, `uint64`, `bool`, `byte`, `float32`, `float64`, `string`.
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- Slices: `[]int`, `[]byte`, `[]string`.
- Maps: `map[string]int`.
- Channels: `chan int`.

Expressions and Operators

- Arithmetic: +, −, *, /, %.
- Relational: ==, !=, >, <, >=, <=.
- Logical: &&, ||, !.
- Bitwise: &, |, ^, <<, >>, &^.

```
// x &^ y == x & (^y)
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- Reference/Dereference: &, *.
- Unary: +, -, ^. `// ^x`
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- Blank identifier: _.

Declarations

- Type declarations *follow* identifier names

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var x int
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func DivideNumbers(x, y int) (int, error) { ... }
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var x int
var UserName string

func AddNumbers(x, y int) int { ... }
func DivideNumbers(x, y int) (int, error) { ... }

type Shape struct {
    X      int
    Y      int
    Color ColorCode
}
```

Program Structure

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- Import packages into the program using the `import` statement.
- Always prefix identifiers from imported packages with their package name.
- Identifiers can be *public* or *private* w/r/t package boundaries.
  - Identifier names starting with an uppercase letter are public.
  - All others are private.

Hello, World

https://go.dev/play/

```
/* Standard-issue "Hello, World" program in Go */

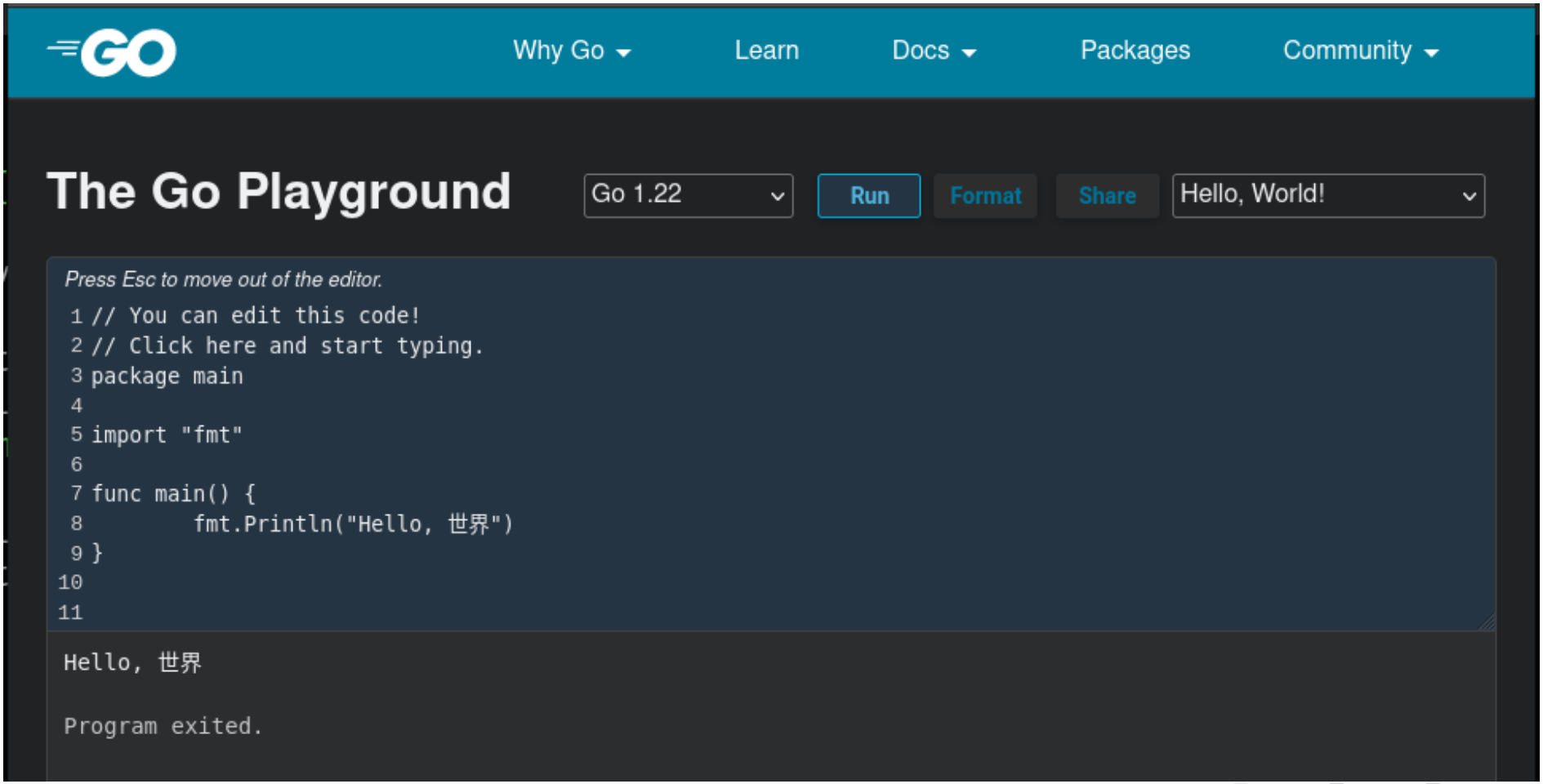
package main

import "fmt"

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

The Playground

- Interactive playground to immediately try something in Go.
- `https://go.dev/play/`



Importing Third-Party Packages

- Standard library package names are simple names:

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import "fmt"
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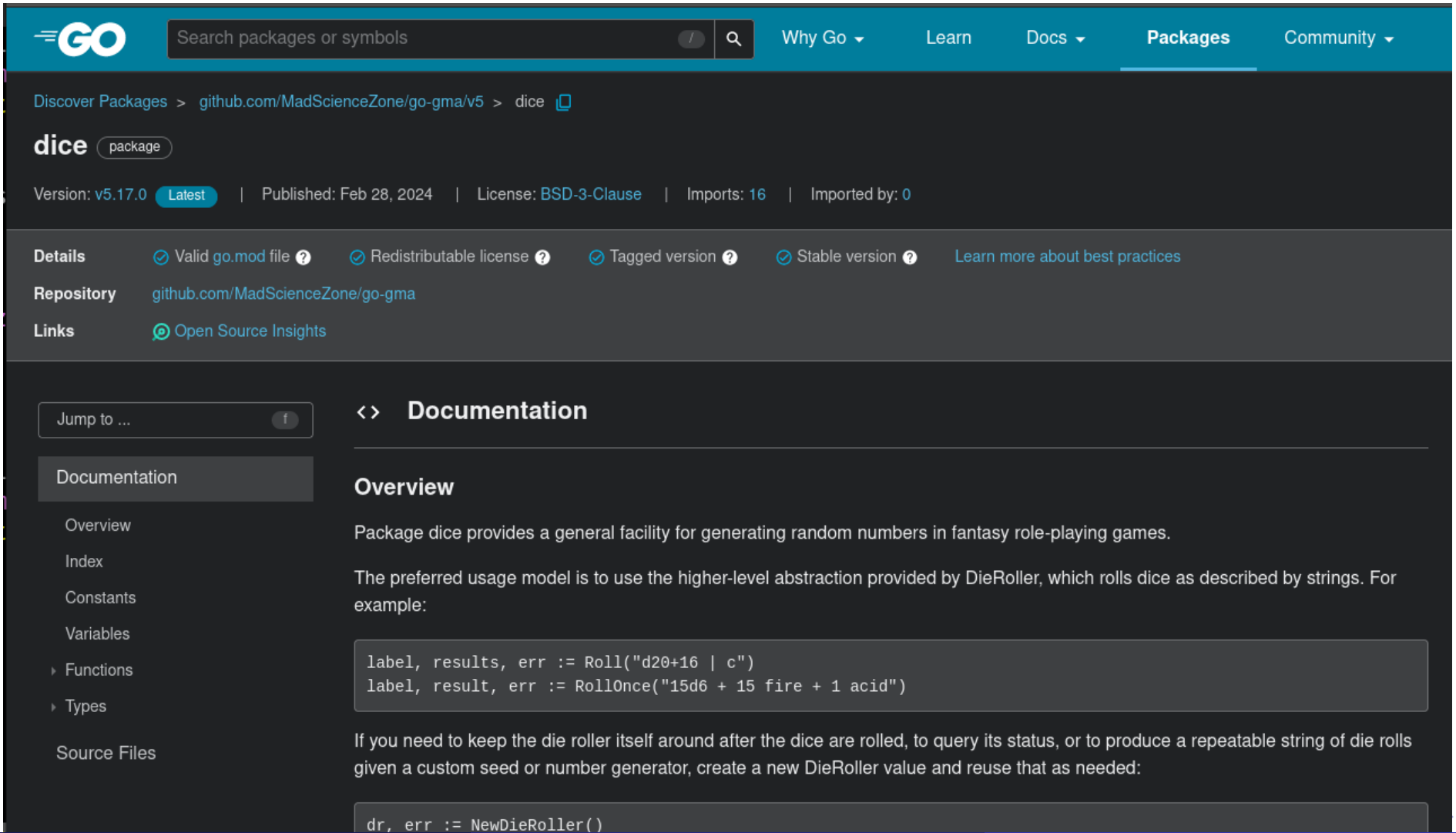
- Getting packages from public repositories:

```
import "github.com/MadScienceZone/go-gma/v5/dice"
```

Automatic API Documentation

- `https://pkg.go.dev/`*repository-url*



"Factored" Notation

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import "fmt"
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import "math"

import (
    "fmt"
    "encoding/json"
    "flag"
    "math"
)
```

"Factored" Notation

```
var initialized bool
var userNames   []string
var Greeting    string   = "Hello"
var TheAnswer            = 42

var (
    initialized bool
    userNames   []string
    Greeting    string   = "Hello"
    TheAnswer            = 42
)
```

"Factored" Notation

```
const initialized        = false
const Greeting           = "Hello"
const TheAnswer    byte  = 42

const (
    initialized        = false
    Greeting           = "Hello"
    TheAnswer    byte  = 42
)
```

"Factored" Notation and iota

https://go.dev/play/p/LSHu1VKUz20

```
type MessageType byte
const (
    ServerCommand MessageType = 0
    ServerReply   MessageType = 1
    ServerError   MessageType = 2
    UrgentMessage MessageType = 3
)
```

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)

const (
    ServerCommand MessageType = iota
    ServerReply   MessageType = iota
    ServerError   MessageType = iota
    UrgentMessage MessageType = iota
)
```

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    ServerReply
    ServerError
    UrgentMessage
)
```

"Factored" Notation and iota Expressions

https://go.dev/play/p/LSHu1VKUz20

```
type MessageType byte
const (
    ServerCommand MessageType = 0x01
    ServerReply   MessageType = 0x02
    ServerError   MessageType = 0x04
    UrgentMessage MessageType = 0x08
)

const (
    ServerCommand MessageType = 1 << iota
    ServerReply
    ServerError
    UrgentMessage
)
```

Conditionals

```
var x int

if x > 10 {
    fmt.Println("X exceeds 10.")
} else {
    fmt.Println("X is tiny.")
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} else {
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}

if x *= 2; x > 10 {
    fmt.Println("Now X is big.")
} else {
    fmt.Println("X is still small.")
}
```

Switches

```
var x int

switch x {
case 0:
    fmt.Println("X is nothing.")
case 1, 3, 5:
    fmt.Println("X is odd.")
case 2, 4, 6:
    fmt.Println("X is even.")
default:
    fmt.Println("X is bigger than I can count.")
}
```

Loops

```go
// infinite loop
for {
}

// while loop
for thing.IsReady() {
}

// traditional 3-part for loop
for i := 0; i < 10; i++ {
}
```

Loops

```
// loop over interval [0,10)
for i := range 10 {
}

// loop over elements of a collection
for i, v := range []int{1, 4, -3, 153} {
}

// loop over data received from channel
for item := range channel {
}
```

Arrays

- The number of elements *is part of the type* (`[10]int` vs. `[15]int`).

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- Variables declared are initialized empty but ready for use

```
var things [5]string

things[0] = "raindrops on roses"
things[1] = "whiskers on kittens"
things[2] = "copper kettles"
things[3] = "woolen mittens"
things[4] = "wild geese"

fmt.Println("I like", things[2])
fmt.Println("I also like", things)
fmt.Println("I know", len(things), "things.")
```

Arrays

https://go.dev/play/p/rexZjp6SdKD

- Or you can specify an array literal value to use in an expression or assign to a variable

```
things := [5]string{
    "raindrops on roses",
    "whiskers on kittens",
    "copper kettles",
    "woolen mittens",
    "wild geese",
}

fmt.Println("I like", things[2])
fmt.Println("I also like", things)
fmt.Println("I know", len(things), "things.")
```

Slices

https://go.dev/play/p/rexZjp6SdKD

- Specify a range [*n*:*m*] as the index into an array to get a subset of the array values with indices from *n* to $m-1$.
- The value is a *slice*, not an *array*. It's a different type.
  - For `[5]string`, the value is `[]string`.

```
fmt.Println("Some things:", things[1:3])
fmt.Println("Some things:", things[:3])
fmt.Println("Some things:", things[1:])
fmt.Println("Some things:", things[:])
```

Slices

https://go.dev/play/p/rexZjp6SdKD

- Dimensionless "arrays": `[]int`.
- Actually a "view" into an underlying array.
  - Go creates and manages the underlying array automatically for you.

```
var things []string
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- Dimensionless "arrays": `[]int`.
- Actually a "view" into an underlying array.
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```
var things []string

things = append(things, "doorbells")
things = append(things, "sleighbells", "schnitzel")
fmt.Println(len(things), things)
// prints:  3 [doorbells sleighbells schnitzel]
```

Slices

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- Can also specify a slice of values as a literal.

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```
things := []string{
    "doorbells",
    "sleighbells",
    "schnitzel",
}

primes := []int{2, 3, 5, 7, 11, 13}
lowPrimes := slices.Delete(primes, 3, len(primes))
fmt.Println(lowPrimes)
// prints:  [2 3 5]
```

Maps

https://go.dev/play/p/Bfs6kEUKwve

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var Ages map[string]int
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var Ages map[string]int
Ages = make(map[string]int)

Ages["Alice"] = 14
Ages["Bob"] = 22
Ages["Charlie"] = 27
Ages["Daria"] = 42
fmt.Println(Ages)
```

Maps

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```
Ages := map[string]int{
    "Alice": 14,
    "Bob": 22,
    "Charlie": 27,
    "Daria": 42,
}
fmt.Println(Ages)

for name, age := range Ages {
    if age >= 18 {
        fmt.Printf("%s may vote.\n", name)
    } else {
        fmt.Printf("%s is not eligible.\n", name)
    }
}
```

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```
aliceAge := Ages["Alice"]       // 14
eveAge := Ages["Eve"]           // 0
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delete(Ages, "Bob")
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Ages["Eve"] = 20
delete(Ages, "Bob")

if _, exists := Ages[name]; exists {
    fmt.Prinln("We do know about", name)
}
```

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aliceAge := Ages["Alice"]        // 14
eveAge := Ages["Eve"]            // 0

aliceAge, exists := Ages["Alice"]        // 14, true
eveAge, exists := Ages["Eve"]            // 0, false

Ages["Eve"] = 20
delete(Ages, "Bob")

if age, exists := Ages[name]; exists {
    fmt.Printf("We know %s's age is %d.\n", name, age)
} else {
    fmt.Println("We don't know", name)
}
```

Error Values

Error Handling

Error Values

```
func main() {
    var intval int
    var err    error

    for i, arg := range os.Args[1:] {
        intval, err = strconv.Atoi(arg)
        if err != nil {
            fmt.Printf("Arg #%d (\"%s\"): %v.\n",
                       i, arg, err)
        } else {
            fmt.Printf("Arg #%d == %d\n", i, intval)
        }
    }
}
```

Object Oriented Features

Wherewith Object Orientation?

(For a language without object classes...)

Structures

https://go.dev/play/p/TClHUvPovi0

```
type Triangle struct {
    Base   int
    Height int
    X      int // Reference point
    Y      int
}
```

Structures

https://go.dev/play/p/TClHUvPovi0

```
type Triangle struct {
    Base   int
    Height int
    X      int // Reference point
    Y      int
}

var t1 Triangle
t1.Base = 37
t1.Height = 15
t1.X = 11
t1.Y = 22
```

Structures

https://go.dev/play/p/TClHUvPovi0

```
type Triangle struct {
    Base   int
    Height int
    X      int // Reference point
    Y      int
}

var t2 Triangle = Triangle{Base: 3, Height: 1}

fmt.Println("t2's base is", t2.Base)
```

Structures

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```
type Triangle struct {
    Base   int
    Height int
    X      int // Reference point
    Y      int
}

t3 := Triangle{
    Base:   100,
    Height: 42,
    X:      -3,
    Y:      14,
}
```

Method Functions

https://go.dev/play/p/TClHUvPovi0

```
func Area(t Triangle) float64 {
    return (float64(t.Base) *
            float64(t.Height)) / 2.0
}

func Translate(t Triangle, dx, dy int) Triangle {
    t.X += dx
    t.Y += dy
    return t
}

fmt.Println("t1 area =", Area(t1))
t2 = Translate(t2, +3, -2)
```

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func Area(t Triangle) float64 {
    return (float64(t.Base) *
            float64(t.Height)) / 2.0
}

func Translate(t *Triangle, dx, dy int) {
    t.X += dx
    t.Y += dy
}

fmt.Println("t1 area =", Area(t1))
Translate(&t2, +3, -2)
```

Method Functions

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```
func (t Triangle) Area() float64 {
    return (float64(t.Base) *
            float64(t.Height)) / 2.0
}

func (t *Triangle) Translate(dx, dy int) {
    t.X += dx
    t.Y += dy
}

fmt.Println("t1 area =", t1.Area())
t2.Translate(+3, -2)
```

Composition

https://go.dev/play/p/qp2nc6gywLr

```
type BaseShape struct {
    X int
    Y int
}

func (s BaseShape) ReferencePoint() (int, int) {
    return s.X, s.Y
}

// (We'll set aside the Translate method for now to
// keep the in-class example simple.)
```

Composition

https://go.dev/play/p/qp2nc6gywLr

```
type Triangle struct {
    BaseShape
    Base   int
    Height int
}

func (t Triangle) Area() float64 {
    return (float64(t.Base) *
            float64(t.Height)) / 2.0
}
```

Composition

https://go.dev/play/p/qp2nc6gywLr

```
type Rectangle struct {
    BaseShape
    Width  int
    Height int
}

func (r Rectangle) Area() float64 {
    return float64(r.Width * r.Height)
}
```

Composition

https://go.dev/play/p/qp2nc6gywLr

```
// Regular Polygons
type Polygon struct {
    BaseShape
    Sides  int
    Length float64  // Length of each side
    Radius float64  // Radius of inscribed circle
}

func (p Polygon) Area() float64 {
    return (float64(p.Sides) / 2.0) *
            p.Length * p.Radius
}
```

Composition

https://go.dev/play/p/qp2nc6gywLr

```
type Circle struct {
    BaseShape
    Radius float64
}

func (c Circle) Area() float64 {
    return math.Pi * math.Pow(c.Radius, 2)
}
```

Polymorphism

https://go.dev/play/p/qp2nc6gywLr

```
shapes := []Shape{
    Triangle{
        BaseShape: BaseShape{
            X: 3,
            Y: 12,
        },
        Base: 3,
        Height: 2,
    },
    Circle{BaseShape:BaseShape{Y: 22}, Radius: 1.5},
    Rectangle{Height: 100, Width: 50},
}
```

Polymorphism

https://go.dev/play/p/qp2nc6gywLr

```
shapes := []Shape{
    Triangle{BaseShape: BaseShape{X: 3, Y: 12},
        Base: 3, Height: 2},
    Circle{BaseShape:BaseShape{Y: 22}, Radius: 1.5},
    Rectangle{Height: 100, Width: 50},
}

for i, shape := range shapes {
    x, y := shape.ReferencePoint()
    fmt.Printf("#%d at (%d,%d), area=%f\n",
                i, x, y, shape.Area())
}
```

Polymorphism via Interfaces

https://go.dev/play/p/qp2nc6gywLr

```
type Shape interface {
    Area() float64
    ReferencePoint() (int, int)
}
```

Polymorphism via Interfaces

https://go.dev/play/p/qp2nc6gywLr

```
type Shape interface {
    Area() float64
    ReferencePoint() (int, int)
}

func reportArea(s Shape) {
    fmt.Printf("The area is %f\n", s.Area())
}
```

Type Assertions

Type Assertions

Type Assertions

https://go.dev/play/p/dy952C3yZUX

```
f(42)
f(-2)

func f(mystery any) {     // any == interface{}
    var v int

    // we know it's an int, just treat it as one
    v = mystery + 15

    fmt.Println("int mystery is", v)
}
```

Type Assertions

https://go.dev/play/p/dy952C3yZUX

```
f(42)
f(-2)

func f(mystery any) {     // any == interface{}
    var v int

    x := mystery.(int)
    v = x + 15

    fmt.Println("int mystery is", v)
}
```

Type Assertions

https://go.dev/play/p/dy952C3yZUX

```
f(42)
f("hello")

func f(mystery any) {     // any == interface{}
    var v int

    x := mystery.(int)
    v = x + 15

    fmt.Println("int mystery is", v)
}
```

Type Assertions

https://go.dev/play/p/dy952C3yZUX

```
f(42)
f("hello")

func f(mystery any) {     // any == interface{}
    var v int

    x, ok := mystery.(int)
    v = x + 15

    fmt.Println("int mystery is", v)
}
```

Type Switch

https://go.dev/play/p/dy952C3yZUX

```
f(42)
f("hello")
func f(mystery any) {     // any == interface{}
    var v int

    switch x := mystery.(type) {
    case int:
        v = x + 15
    case string:
        fmt.Println("string", x)
    default:
        // handle the unknown type
    }
}
```

Goroutines

Concurrency!

(Goroutines and Channels and some other things)

Goroutines—Calling a Function in the "Background"

https://go.dev/play/p/FJNbOcNYI8-

```
func countdown() {
    for i := 10; i >= 0; i-- {
        fmt.Printf(">>> %d <<<\n", i)
        time.Sleep(1 * time.Second)
    }
}
```

Goroutines—Calling a Function in the "Background"

https://go.dev/play/p/FJNbOcNYI8-

```
func countdown() {
    for i := 10; i >= 0; i-- {
        fmt.Printf(">>> %d <<<\n", i)
        time.Sleep(1 * time.Second)
    }
}

func main() {
    countdown()
    fmt.Println("Starting a long-running task...")
    time.Sleep(15 * time.Second)
    fmt.Println("Done. Exiting.")
}
```

Goroutines—Calling a Function in the "Background"

https://go.dev/play/p/FJNbOcNYI8-

```
func countdown() {
    for i := 10; i >= 0; i-- {
        fmt.Printf(">>> %d <<<\n", i)
        time.Sleep(1 * time.Second)
    }
}

func main() {
    go countdown()
    fmt.Println("Starting a long-running task...")
    time.Sleep(15 * time.Second)
    fmt.Println("Done. Exiting.")
}
```

Channels

https://go.dev/play/p/sFuhOuwVS6c

```
ch := make(chan byte)
```

Channels

https://go.dev/play/p/sFuhOuwVS6c

```
ch := make(chan byte)

fmt.Println("Writing to channel")

ch <- 42

fmt.Println("Reading from channel")
x := <-ch
fmt.Println("Read", x, "from channel")
```

Channels

https://go.dev/play/p/sFuhOuwVS6c

```
ch := make(chan byte)

fmt.Println("Writing to channel")

ch <- 42          // DEADLOCKED!

fmt.Println("Reading from channel")
x := <-ch
fmt.Println("Read", x, "from channel")
```

Channels

https://go.dev/play/p/sFuhOuwVS6c

```
ch := make(chan byte)
go func(c chan byte) {
    x := <-c
    fmt.Println("Read", x, "from channel")
}(ch)

fmt.Println("Writing to channel")
ch <- 42
```

Buffered Channels

https://go.dev/play/p/sFuhOuwVS6c

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

Buffered Channels

https://go.dev/play/p/sFuhOuwVS6c

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

fmt.Println("Writing to channel")
ch <- 42

fmt.Println("Reading from channel")
x := <-ch
fmt.Println("Read", x, "from channel")
```

Select

Select

Select (C)

```c
#include <sys/select.h>
fd_set read_handles, write_handles, err_handles;
struct timeval t;
int sel = 0;

FD_ZERO(&read_handles);
FD_ZERO(&write_handles);
FD_ZERO(&err_handles);
/* set bits for handles you're interested in */
t.tv_sec = 1;
t.tv_usec = 0;
```

Select (C)

```
if ((sel = select(maxfd, &read_handles,
                  &write_handles,
                  &err_handles, &t)) == -1) {
    /* error... */
}
else if (sel > 0) {
    /* go back and check the bits in *_handles */
}
```

Select (Go)

```
select {
case x := <-ichan:
    // we could read from ichan, proceed
    // with that...

case ochan <- ovalue:
    // we could write to ochan

}
```

Select (Go)

```
select {
case x := <-ichan:
    // we could read from ichan, proceed
    // with that...

case ochan <- ovalue:
    // we could write to ochan

default:
    // if we don't want the whole select to
    // block, add a default case here.

}
```

Global ID Generation Examples

Thread-Safe Memory Access

by example

Global ID Generation (Naïve)

https://go.dev/play/p/iOxsFX_TSaa

```
type GameState struct {
    NextMessageID int
}
```

Global ID Generation (Naïve)

https://go.dev/play/p/iOxsFX_TSaa

```
type GameState struct {
    NextMessageID int
}

var gameserver GameState

// In many concurrent goroutines...

gameServer.NextMessageID++
client.ID = gameServer.NextMessageID
```

Global ID Generation (Naïve)

https://go.dev/play/p/iOxsFX_TSaa

```
type GameState struct {
    NextMessageID int
}

var gameserver GameState

// In many concurrent goroutines...

gameServer.NextMessageID++                  // UNSAFE!
client.ID = gameServer.NextMessageID        // UNSAFE!
```

Global ID Generation (Mutex)

https://go.dev/play/p/iOxsFX_TSaa

```
type GameState struct {
    nextMessageID int
    lock          sync.Mutex
}

func (state *GameState) GetNextID() int {




}

// in many random goroutines...
client.ID = gameServer.GetNextID()
```

Global ID Generation (Mutex)

https://go.dev/play/p/iOxsFX_TSaa

```
type GameState struct {
    nextMessageID int
    lock          sync.Mutex
}

func (state *GameState) GetNextID() int {
    state.lock.Lock()
    state.nextMessageID++
    nextID := state.MessageID
    state.lock.Unlock()
    return nextID
}

// in many random goroutines...
client.ID = gameServer.GetNextID()
```

Global ID Generation (Mutex)

https://go.dev/play/p/iOxsFX_TSaa

```
type GameState struct {
    nextMessageID int
    lock          sync.Mutex
}

func (state *GameState) GetNextID() int {
    state.lock.Lock()
    defer state.lock.Unlock()

    state.nextMessageID++
    return state.nextMessageID
}

// in many random goroutines...
client.ID = gameServer.GetNextID()
```

Global ID Generation (Mutex)

https://go.dev/play/p/iOxsFX_TSaa

```
func main() {
    var gameServer GameState
    var wg         sync.WaitGroup
    for i := range 100 {
        wg.Add(1)
        id := i
        go func() {
            defer wg.Done()
            fmt.Printf("Goroutine #%d, ID=%d\n", id,
                gameServer.GetNextID())
        }()
    }
    wg.Wait()
}
```

Global ID Generation (Channel)

But that's not very idiomatic for Go.

Here's a much better approach...

Global ID Generation (Channel)

https://go.dev/play/p/mRfglxbH-kI

```
func serveMessageIDs(c chan<- int) {
    var id int
    for {
        c <- id
        id++
    }
}
```

Global ID Generation (Channel)

https://go.dev/play/p/mRfglxbH-kI

```
func serveMessageIDs(c chan<- int) {
    var id int
    for {
        c <- id
        id++
    }
}

// start up the service
IDSource := make(chan int)
go serveMessageIDs(IDSource)
```

Global ID Generation (Channel)

https://go.dev/play/p/mRfglxbH-kI

```
func serveMessageIDs(c chan<- int) {
    var id int
    for {
        c <- id
        id++
    }
}

// start up the service
IDSource := make(chan int)
go serveMessageIDs(IDSource)

// In many random goroutines...
client.ID = <-IDSource
```

Bonus/Backup Material

Some more cool stuff if time allows...

Contextx

Contexts

Contexts

https://go.dev/play/p/cPSNhVfS8r-

```
func collectData(stream <-chan string) error {
    for {
        data, ok := <-stream
        if !ok {
            return nil
        }
        if err := doSomething(data); err != nil {
            return err
        }
    }
}

// elsewhere
collectData(stream)
```

Contexts

https://go.dev/play/p/cPSNhVfS8r-

```
func collectData(ctx context.Context,
                 stream <-chan string) error {
    for {
        select {
        case <-ctx.Done():
            return nil
        case data, ok := <-stream:
            if !ok { return nil }
            if err := doSomething(data); err != nil {
                return err
            }
        }
    }
}
```

Contexts

https://go.dev/play/p/cPSNhVfS8r-

```
// caller

ctx, cancel := context.WithTimeout(
    context.Background(), 5 * time.Second)
defer cancel()

if err := collectData(ctx, stream); err != nil {
    panic(err)
}
```

Contexts

https://go.dev/play/p/cPSNhVfS8r-

```
func collectData(ctx context.Context,
                 stream <-chan string) error {
    for {
        select {
        case <-ctx.Done():
            return nil
        case <-time.After(2 * time.Second):
            log.Print("collectData taking too long")
        case data, ok := <-stream:
            if !ok { return nil }
            if err := doSomething(data); err != nil {
                return err
            }
        }}}
```

JSON

Encoding (JSON)

JSON

https://go.dev/play/p/_KcMkqhhzbZ

```
import "encoding/json"
type User struct {
    Name   string   `json:"name"`
    ID     int      `json:",omitempty"`
    Attrs  []string `json:"attributes,omitempty"`
    Secret []byte   `json:"-"`
}
data := User{
    Name: "steve",
    ID: 42,
    Attrs: []string{"foo","bar"},
    Secret: sdata,
}
```

JSON

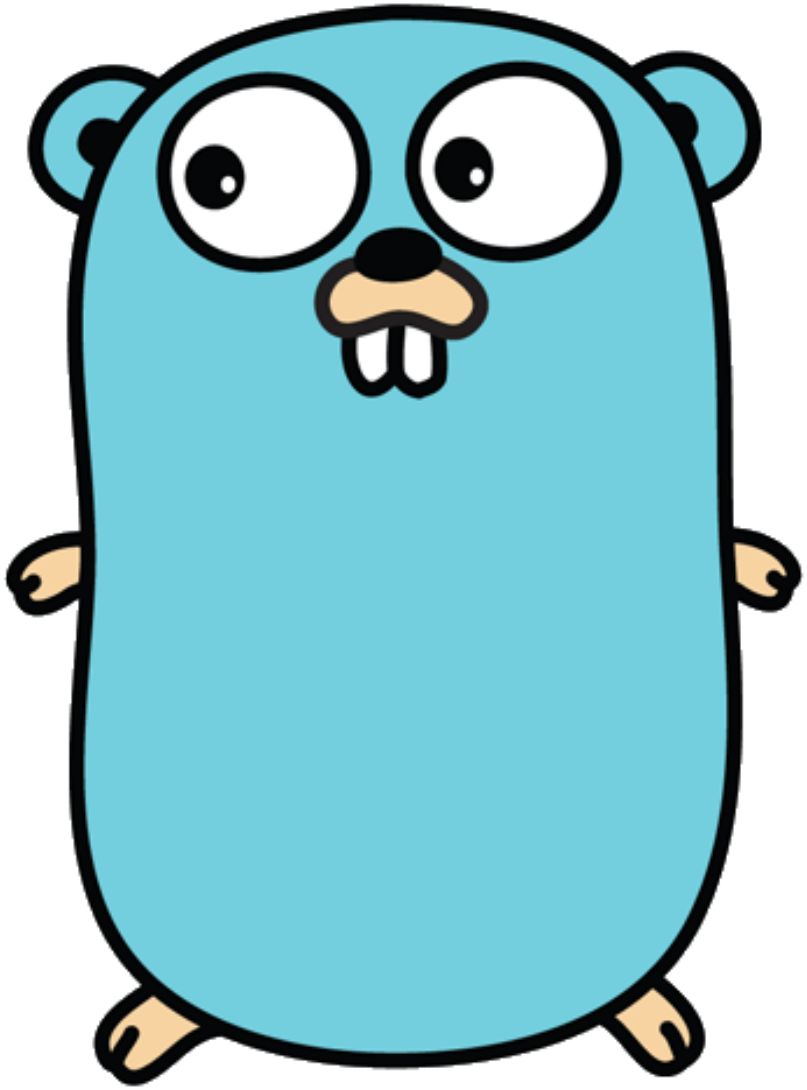
https://go.dev/play/p/_KcMkqhhzbZ

```
import "encoding/json"

type User struct {
    Name   string   `json:"name"`
    ID     int      `json:",omitempty"`
    Attrs  []string `json:"attributes,omitempty"`
    Secret []byte   `json:"-"`
}

encoded, err := json.Marshal(data)
// {"name":"steve","ID":42,"attributes":["foo","bar"]}

var inputData User
err := json.Unmarshal(jsonBytes, &inputData)
```



github.com/MadScienceZone/go-tour