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Lecture 14: Pointers

Suppose we store information and employees and teams using the following types:

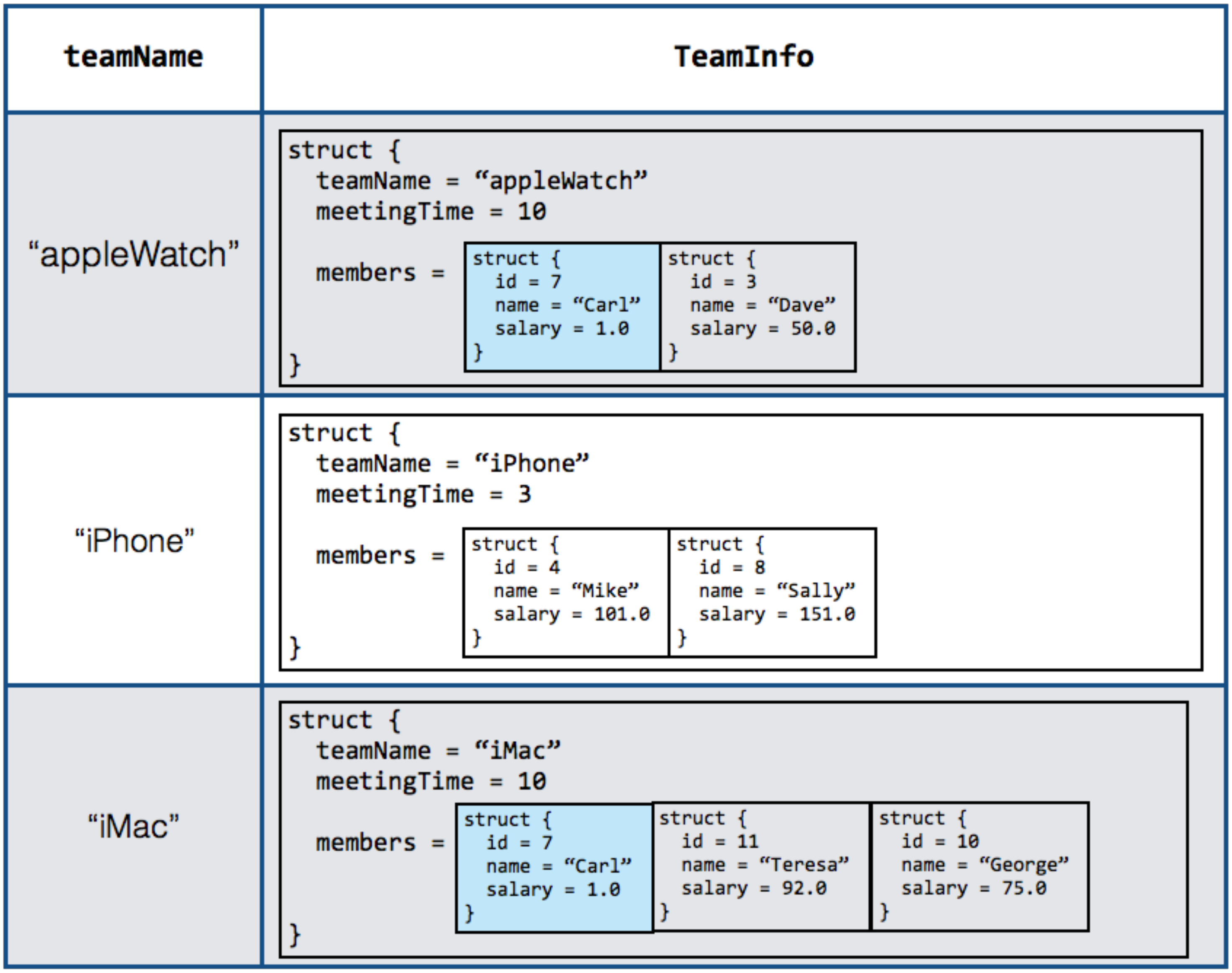
```go
type TeamInfo struct {
    teamName string
    meetingTime int
    members []Employee // note difference from class!
}

type Employee struct {
    id int
    name string
    salary float64
}
```

We can then store all the info about the company in a map from team names to `TeamInfo` structures:

```go
company := make(map[string]TeamInfo)

company["appleWatch"] = TeamInfo{
    teamName: "appleWatch",
    meetingTime: 10,
    members: []Employee{
        Employee{id: 7, name: "Carl", salary: 1.0},  // DUP!!!
        Employee{id: 3, name: "Dave", salary: 50.0},
        },
}

company["iPhone"] = TeamInfo{
    teamName: "iPhone",
    meetingTime: 3,
    members: []Employee{
        Employee{id: 4, name: "Mike", salary: 101.0},
        Employee{id: 8, name: "Sally", salary: 151.0},
    },
}

company["iMac"] = TeamInfo{
    teamName: "iMac",
    meetingTime: 10,
    members: []Employee{
        Employee{id: 7, name: "Carl", salary: 1.0},     // DUP!!!
        Employee{id: 10, name: "George", salary: 75.0},
        Employee{id: 11, name: "Teresa", salary: 92.0},
    },
}
```

Notice the lines marked with `// DUP!!!` : there are two entries for Carl because he is on two different teams. This is a waste of space, error prone because you must update each duplicate if any of the data changes, and slower because you always have to search for every duplicate.

The above structure of the data can be visualized as:

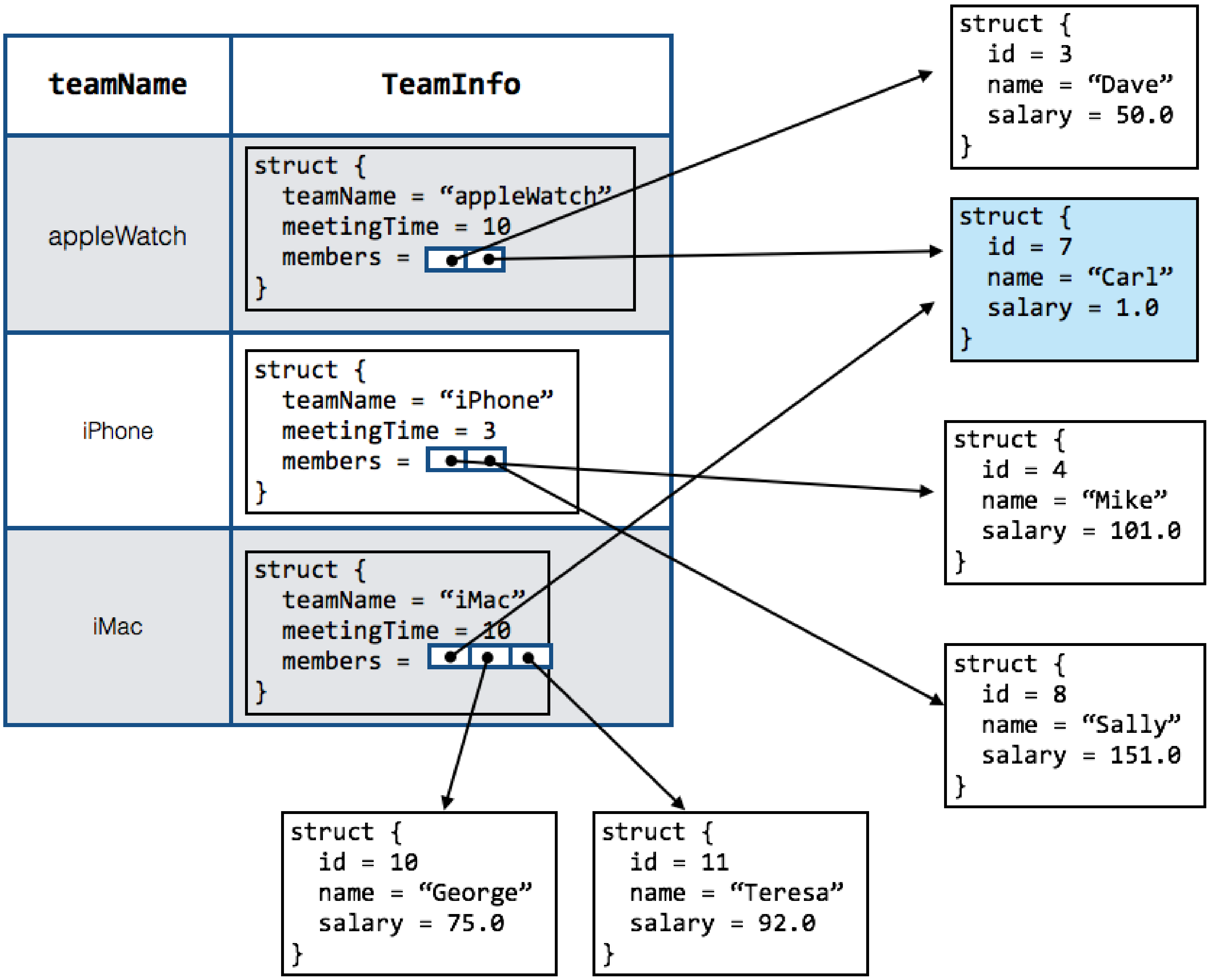


teamName	TeamInfo
“appleWatch”	struct { teamName = “appleWatch” meetingTime = 10 members = struct { id = 7 name = “Carl” salary = 1.0 } struct { id = 3 name = “Dave” salary = 50.0 } }
“iPhone”	struct { teamName = “iPhone” meetingTime = 3 members = struct { id = 4 name = “Mike” salary = 101.0 } struct { id = 8 name = “Sally” salary = 151.0 } }
“iMac”	struct { teamName = “iMac” meetingTime = 10 members = struct { id = 7 name = “Carl” salary = 1.0 } struct { id = 11 name = “Teresa” salary = 92.0 } struct { id = 10 name = “George” salary = 75.0 } }

In class, we saw a fix to this that used the employee id to link employees into the teams. This situation is common enough, that most programming languages have a solution for it, which is pointers.

Pointers

We'd like to change the `TeamInfo` type so that each employee is represented once:



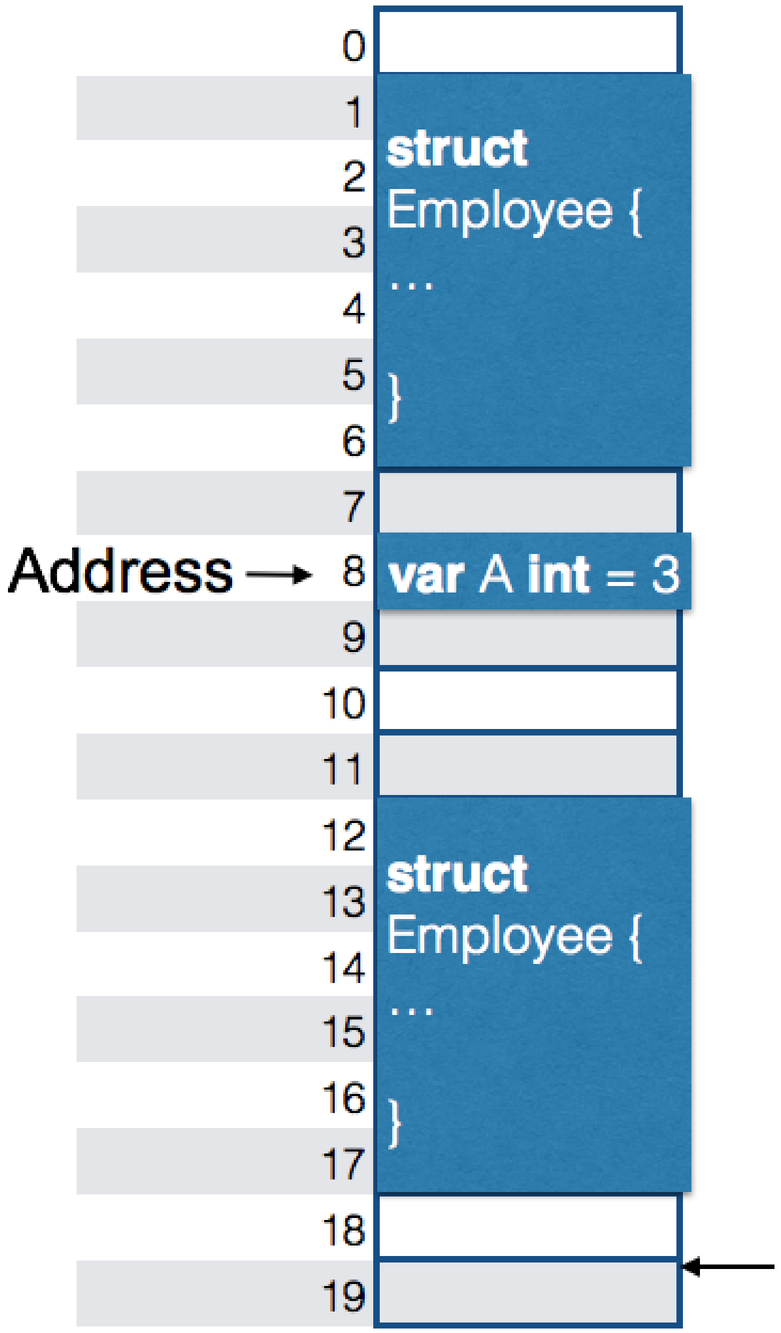
The way we can do this is to change the `TeamInfo` type to:

```
type TeamInfo struct {
  teamName string
  meetingTime int
  members []*Employee    // the "*" means "pointer"
}
```

The `[]*Employee` type is a list (`[]`) of pointers (`*`) to `Employees` .

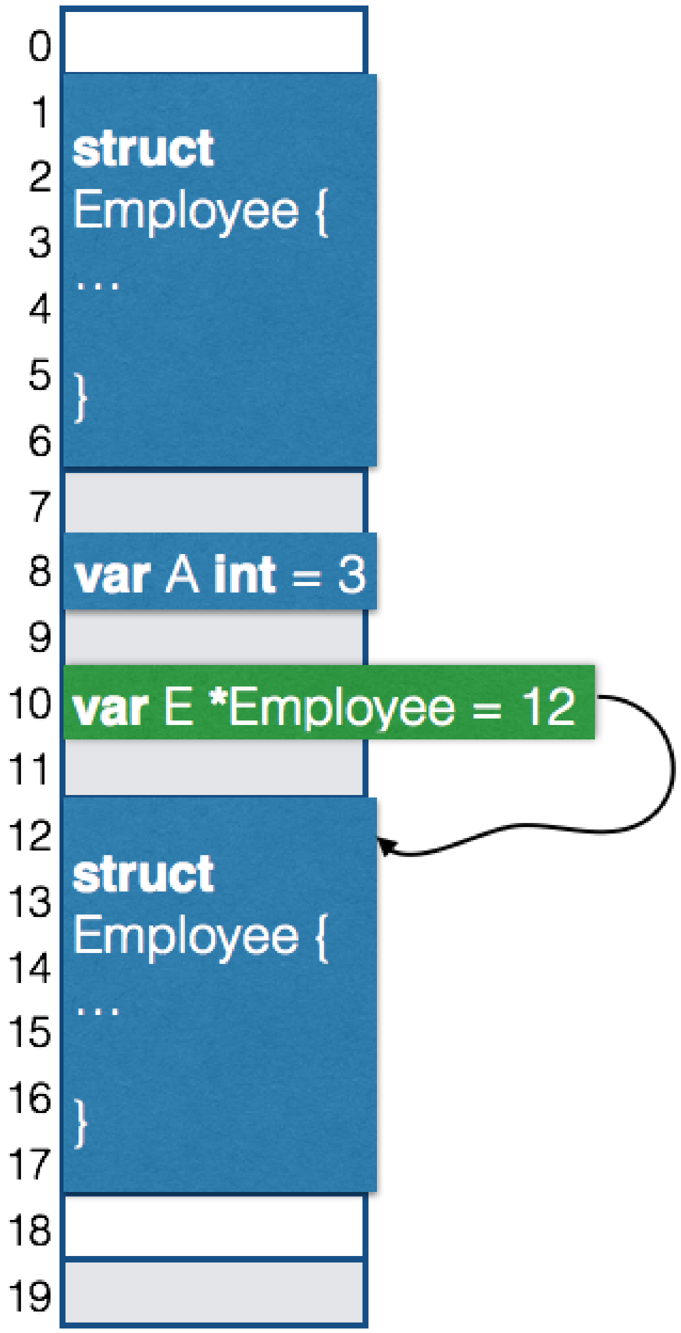
What is a pointer?

Your computer's memory is a long chain of cells numbered 0 to some large number. Each variable you declare take up some number of these cells:



The location of the variable is called its address.

A pointer is a variable that contains the address of some other variable:



Setting what a pointer points to

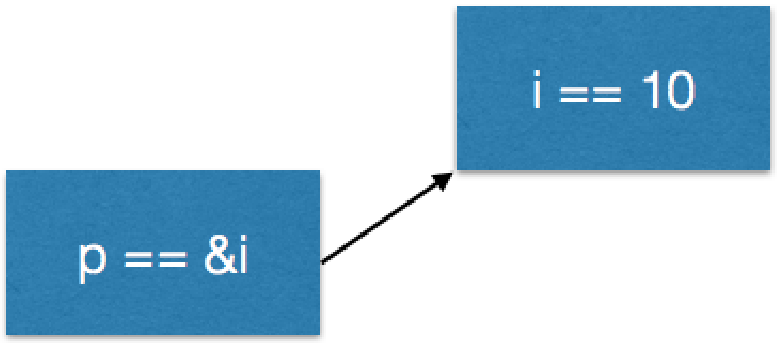
A pointer is a variable that contains an address of another variable. To get the address of a variable you use the `&` (address) operator:

```go
var P Employee = createEmployee()
var person *Employee

// at this point, person == nil

person = &P
```

Another example:

```go
var i int = 10
var p *int = &i
```

This creates the following situation:



Accessing the value of the variable that a pointer points to

Suppose you have the following statements:

```go
var i int = 10
var p *int = &i
```

Then `i` 's value is 10 and `p` 's value is the address of `i` . If you `fmt.Println(p)` you will get some large integer (probably in hexadecimal) that is the memory address where `i` is stored. If, however, you do

```go
fmt.Println(*p)
```

you will print out "10". The `*` operator, when put before a pointer means "follow the pointer". The expression `*p` acts almost exactly like `i` . Consider the following statements:

```go
fmt.Println(*p) // will print "10"
*p = 20
fmt.Println(*p) // will print "20"
fmt.Println(i) // will print "20" ****
```

Assigning to `*p` is exactly the same thing as assigning to `i`. And `*p` is really just another name for `i`. It's sort of like `i` is "The White House" and `*p` is "1600 Pennsylvania Avenue".

Here's an another example sequence of statements using pointers:

```go
var i int = 10
var j int = 10
var p *int = &i

i = 11
fmt.Println(*p)
fmt.Println(p)

*p = 300
fmt.Println(*p)
fmt.Println(p)
fmt.Println(i)

p = &j
fmt.Println(*p)
*p = 12
fmt.Println(*p)
```

> **Test Yourself!** Write down what each `Println` statement above will print out and then check your answers by running the above statements in Go.

Other pointers

You can have pointers to any variable:

```go
var name *string              // ptr to string
var person *Employee          // ptr to Employee
var pj *int                   // ptr to int
var m map[string]*Employee    // map from strings to pointers to Employees
var pA *[]float64             // a ptr to a list of real numbers
var Apf []*float64            // a list of pointers to real numbers
```

Pointers are "meta" things. An `Employee` is a piece of data, an "object" of your program. A `*Employee` is a reference to that object. A variable of type `*Employee` is **not** an `Employee`.

René Magritte

Pointers to `struct` s

Just as with our `Employee` example, it is often the case that you have a pointer to a variable that holds a `struct`:

```go
var P Employee = createEmployee()
var person *Employee // at this point, person == nil

person = &P // now person points to P

(*person).name = "Jerry"
```

The statement `(*person).name` means: follow the `person` pointer; you arrive at a `struct` of type `Employee`; access the field `name` of that `struct`. This is so common, Go provides a shortcut:

```go
person.name = "Jerry"
```

You can access the fields of a struct from a pointer to that struct just as if you had the struct directly.

Another example:

```go
type Contact struct {
   name string
   id int
}

func main() {
   // c is a Contact structure
   var c Contact = Contact{name:"Dave", id:33}

   // p points to c
   var p *Contact = &c

   fmt.Println(c)   // will print out contents of c
   fmt.Println(*p)  // will *also* print out context of c
   (*p).name = "Holly"    // will change c.name to "Holly"
   p.id = 33              // will change c.id to 33
   fmt.Println(*p)
}
```

Passing a `struct` to a function:

What's wrong with this code?

```go
// BAD CODE BAD CODE BAD CODE
type Contact struct {
    name string
    id int
}

func setContactInfo(d Contact) {
    d.name = "Holly Golightly"
    d.id = 101
}

func main() {
    var c Contact = Contact{name:"Dave", id:33}
    setContactInfo(c)
    fmt.Println(c)
}
// BAD CODE BAD CODE BAD CODE
```

When we pass `c` into `setContactInfo` we are passing in a copy, so any changes we make to `d` inside of `setContactInfo` don't effect `c`. How can we fix it?

Have the function take a pointer to a `Contact` and then pass the **address** of `c` into the function:

```go
type Contact struct {
    name string
    id int
}

func setContactInfo(c *Contact) { // NOTE *
    c.name = "Holly Golightly"
    c.id = 101
}

func main() {
    var c Contact = Contact{name:"Dave", id:33}
    setContactInfo(&c) // NOTE &
    fmt.Println(c)
}
```

Summary

Pointers store addresses of other variables. Declare by prefixing type with * Access the variable they point to by prefixing the pointer with * Get the address of a variable (to assign to a pointer) via & Most common use: pointers to structures

Glossary

- address: the location in memory of a variable.
- pointer: a variable that holds the address of another variable.
- dereference: means "following the pointer" and is denoted `*p` when `p` is a pointer.
- address of operator: `&x` returns the address of variable `x`.