Conditionals & Loops

02-201 / 02-601

Conditionals

If Statement

if statements let you execute statements conditionally.

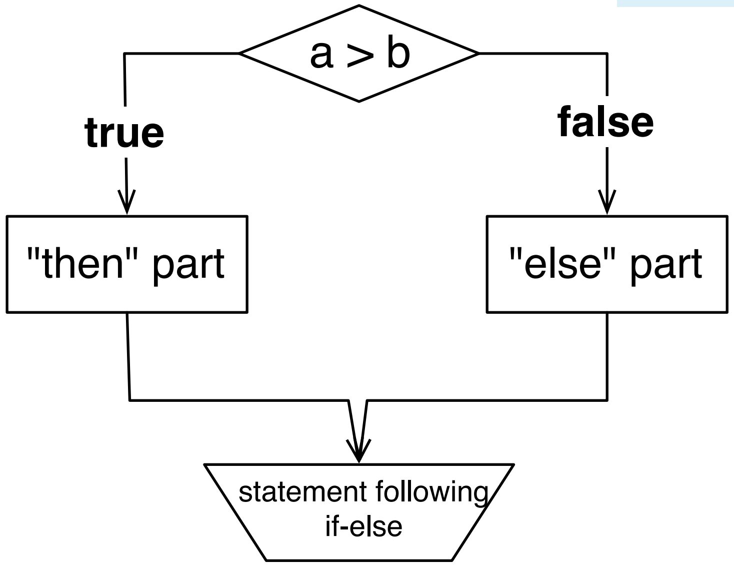
```
func max(a int, b int) int {
     var m int
     if a > b {
         m = a
         fmt.Println(a)
     } else {
         m = b
         fmt.Println(b)
     }
     return m
}
```

condition

"then" part: executed if the condition is TRUE

"**else**" part: executed if the condition is FALSE

else part is optional.



If statements let you make choices:

if the condition is true, the else part will be skipped;

if the condition is false, the then part will be skipped.

Conditions

```
if a > b {
     m = a
     fmt.Println(a)
} else {
     m = b
     fmt.Println(b)
}
```

Boolean Operator	Meaning
e	e_1
e	e_1
e	e_1
e	e_1
e	e_1
e	e_1
!e	true if and only if e

e_1 and e_2 can be complicated expressions

Example conditions:

```
a > 10 * b + c
10 == 10
square(10) < 101 - 1 + 2
!(x*y < 33)
```

Boolean expressions: because they evaluate to true or false

Boolean Operators: AND and OR

Boolean Operator	Meaning
e	true if e
e	true if e

“pipe” character |
Often above \ on
your keyboard

Boolean Expressions:

Examples, true or false?

```
a=10
b=50
```

`a>10 && b > 20` **false**

`a==10 && b < 100 && a*b > 1000` **false**

`a>20 || b < 51 || b-a*b > 0` **true**

`a=10 && b=50` **syntax error!**

`a==10 && b >= 100 || b == 50` **true**

`b==50 || a == 10 && b >= 100` **true**

`a>5 && b>20 || a==0 && b==0` **true**

`a>5 || b>20 && a==0 || b==0` **false**

`a>5 || (b>20 && a==0) || b==0` **true**

Example “if” statements

```
// max() returns the larger of 2 ints
func max(a,b int) int {
   if a > b {
      return a
   }
   return b
}
```

```
// max() returns the larger of 2 ints
// equivalent to above
func max(a,b int) int {
   if a > b {
      return a
   } else {
      return b
   }
}
```

{ must be on same line as **if**
} and { must be on same line as **else**

```
if temperature > 100 {
   fmt.Println(“Warning: too hot!”)
}
```

```
var a,b int = 3,3

if a < 10 {
   a = a*a
}
if a * a > 3*b {
   t := a
   a = b
   b = t
}
if a < b {
   fmt.Println(a)
} else {
   fmt.Println(b)
}
```

Q: What will this print?

A: 3

```
// AbsInt() computes the absolute value of an integer.
func AbsInt(x int) int {
     if x < 0 {
          return -x
     }
     return x
}
```

Another If Example

```
// returns the smallest even number
// among 2 ints; returns 0 if both are odd
func smallestEven(a, b int) int {
   if a % 2 == 0 {
      if b % 2 == 0 {
         // both a and b are even, so
         // return smaller one
         if a < b {
            return a
         } else {
            return b
         }
      } else {
         // only a is even
         return a
      }
   } else if b % 2 == 0 {
      // only b is even
      return b
   } else {
      // both a and b are odd
      return 0
   }
}
```

% is the “modulus” operator: `a % b` is the *remainder* when integer a is divided by integer b.

Can put an **if** directly following an **else**. This is equivalent to:

```
if a % 2 == 0 {
    …
} else {
   if b % 2 == 0 {
     …
   }
}
```

but uses one fewer set of {} so it’s shorter to type.

Switch statement

switch statements let you express several, mutually exclusive tests compactly.

```
// even() returns the smallest even number
// among 2 ints; returns 0 if both are odd
func smallestEven(a, b int) int {
   switch {
   case a % 2 && b % 2:
      if a < b {
         return a
      } else {
         return b
      }
   case a % 2 == 0:
      fmt.Println(“Returning a”)
      return a
   case b % 2 == 0:
      return b
   default:
      return 0
   }
}
```

Each **case** part contains a condition, followed by a “:” and then a sequence of statements.

The statements associated with the *first true* case will be executed.

Q: would it be ok to swap the first and second cases in smallestEven()?

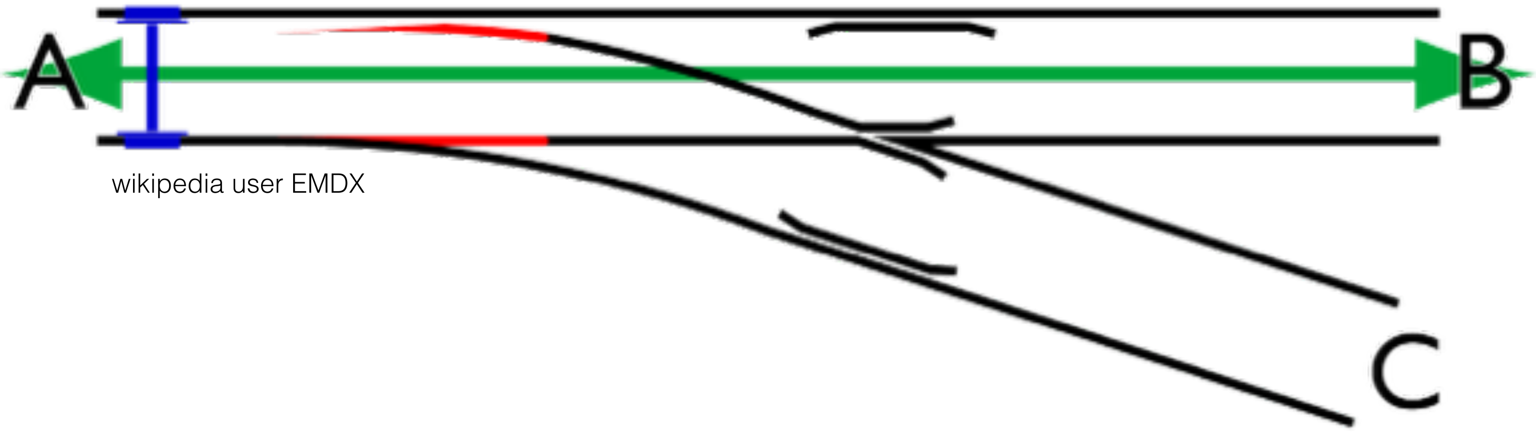
No!

The optional **default** case is executed if none of the others are.

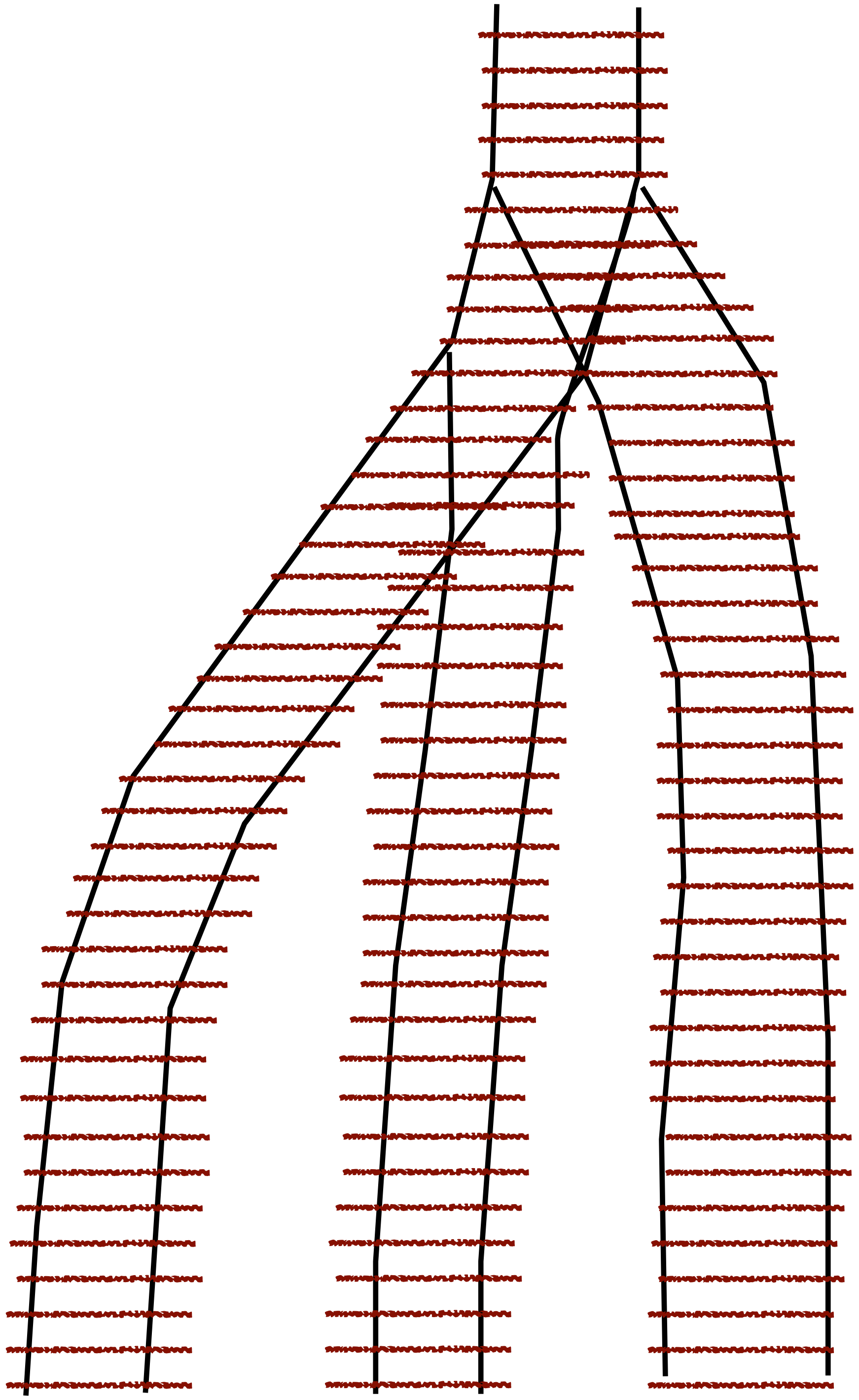
switch statements in Go are much more powerful than those in Java, C, and C++.

Why are they called switch statements?

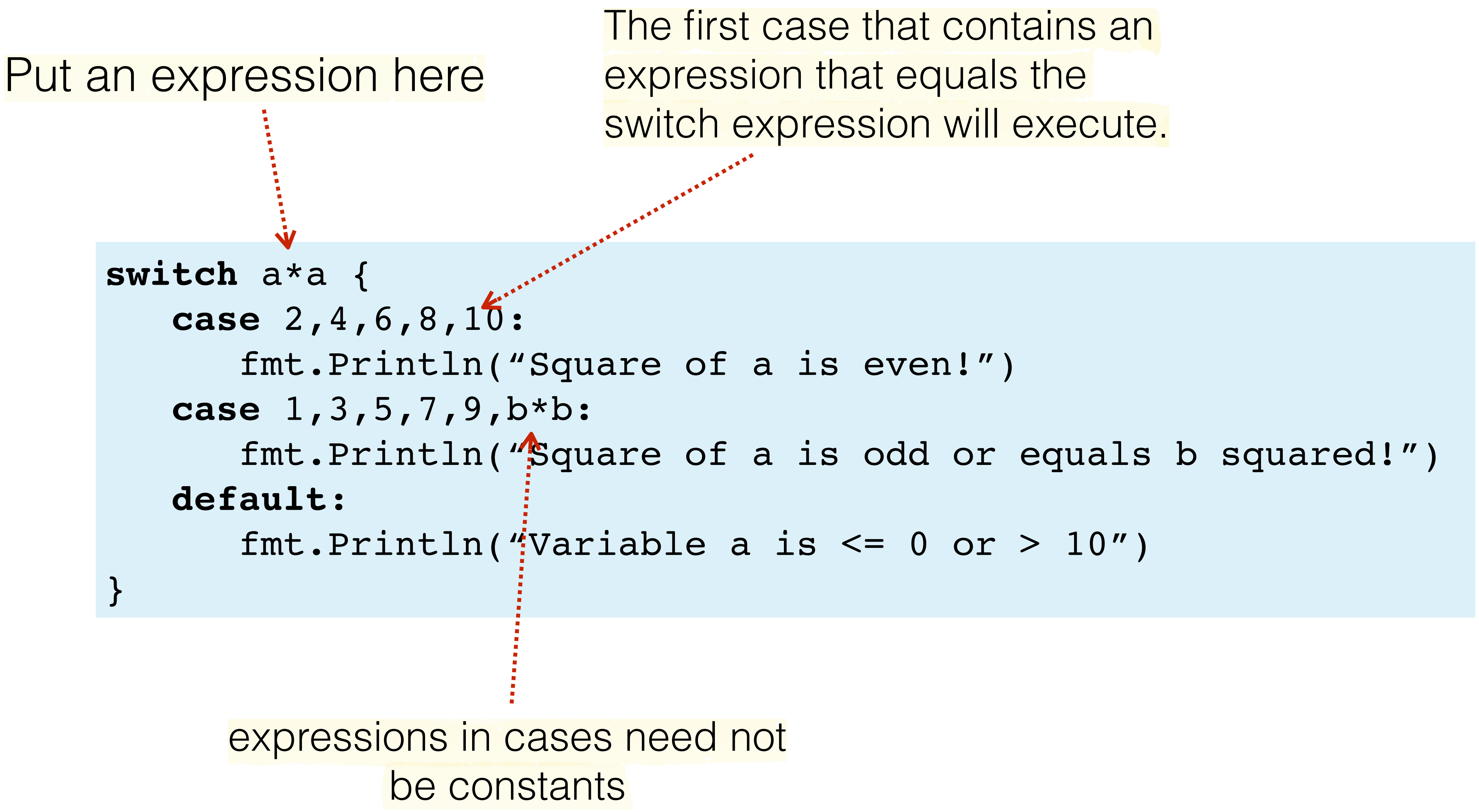
Analogy: a railroad switch: depending on the condition of the switch, the train will go down a different track.



wikipedia user EMDX



General Switch Statements



Put an expression here

The first case that contains an expression that equals the switch expression will execute.

```
switch a*a {
   case 2,4,6,8,10:
      fmt.Println(“Square of a is even!”)
   case 1,3,5,7,9,b*b:
      fmt.Println(“Square of a is odd or equals b squared!”)
   default:
      fmt.Println(“Variable a is <= 0 or > 10”)
}
```

expressions in cases need not be constants

Example

Convert a character of DNA into an integer representation:

Documentation for function

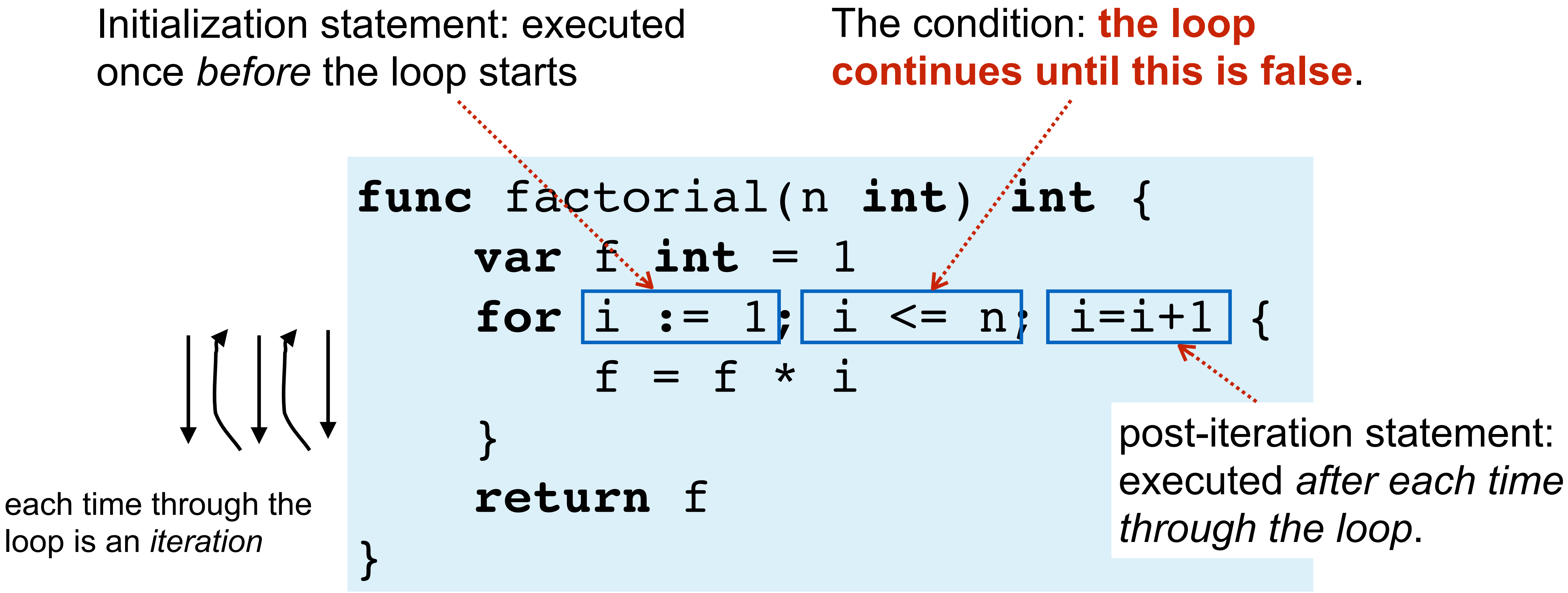
```
// acgt() takes a letter and returns the index in 0,1,2,3 to which it is
// mapped. 'N's become 'A's and any other letter induces a panic.
func acgt(a byte) byte {
    switch a {
    case 'A':
        return 0
    case 'N':
        return 0
    case 'C':
        return 1
    case 'G':
        return 2
    case 'T':
        return 3
    }
    panic(fmt.Errorf("Bad character: %s!", string(a)))
}
```

We'll see **byte**, **string**, and **panic** later.

Loops

Loops

- Loops let you repeat statements.
- The statements in the body of the loop will be executed until the loop condition is false.
- Go has only “one” kind of loop: the **for** loop, with 2 different forms.



Initialization statement: executed once *before* the loop starts

The condition: **the loop continues until this is false**.

```
func factorial(n int) int {
    var f int = 1
    for i := 1; i <= n; i=i+1 {
        f = f * i
    }
    return f
}
```

each time through the loop is an *iteration*

post-iteration statement: executed *after each time through the loop*.

“while” loops

- You can omit the initialization statement and the post-iteration statement in a **for** loop.
- This form is sometimes called a “while” loop, because it loops “while the condition is true”
- These two code snippets are *almost* equivalent:

```
var f int = 1
for i := 1; i <= n; i=i+1 {
   f = f * i
}
```

```
var f int = 1
i := 1
for i <= n {
   f = f * i
   i = i + 1
}
```

- Can you guess the difference?

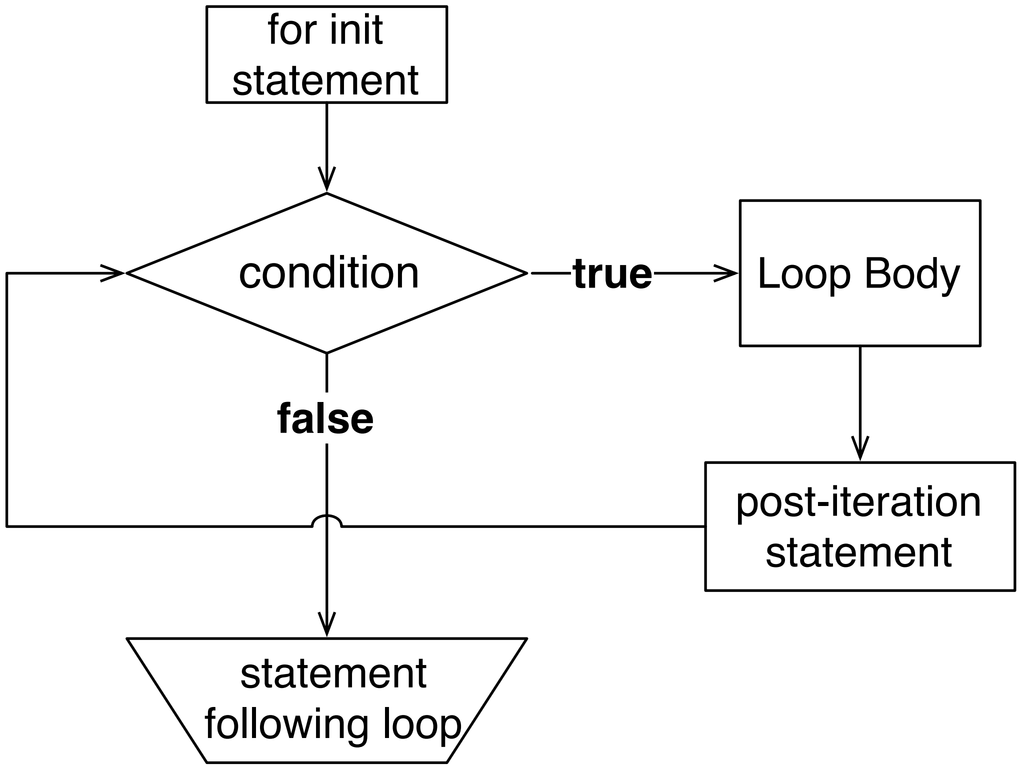
Answer: Scope! of the `i` variable

In the first: the `i` variable’s scope is only the body of the **for** loop

In the second: `i` lasts until the end of the enclosing scope

For Loop Control Flow

```
var f int = 1
for i := 1; i <= n; i=i+1 {
   f = f * i
}
```

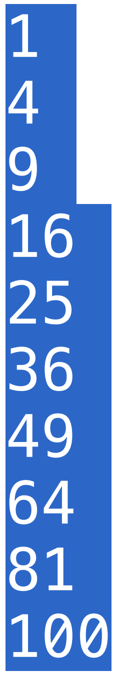


Variable Definitions in Loop Bodies

What will the following function print?
Is it correct?

```
func sumSquares() {
    // print partial sums of the sequence of squares
    // of the numbers 1 to 10
    for i := 1; i <= 10; i = i + 1 {
        var j int
        j = j + i * i
        fmt.Println(j)
    }
}
```

This is wrong!
It will print:



```
1
4
9
16
25
36
49
64
81
100
```

which are the first 10 squares, not their sums

Why?

Variable `j` is created and destroyed each time through the loop

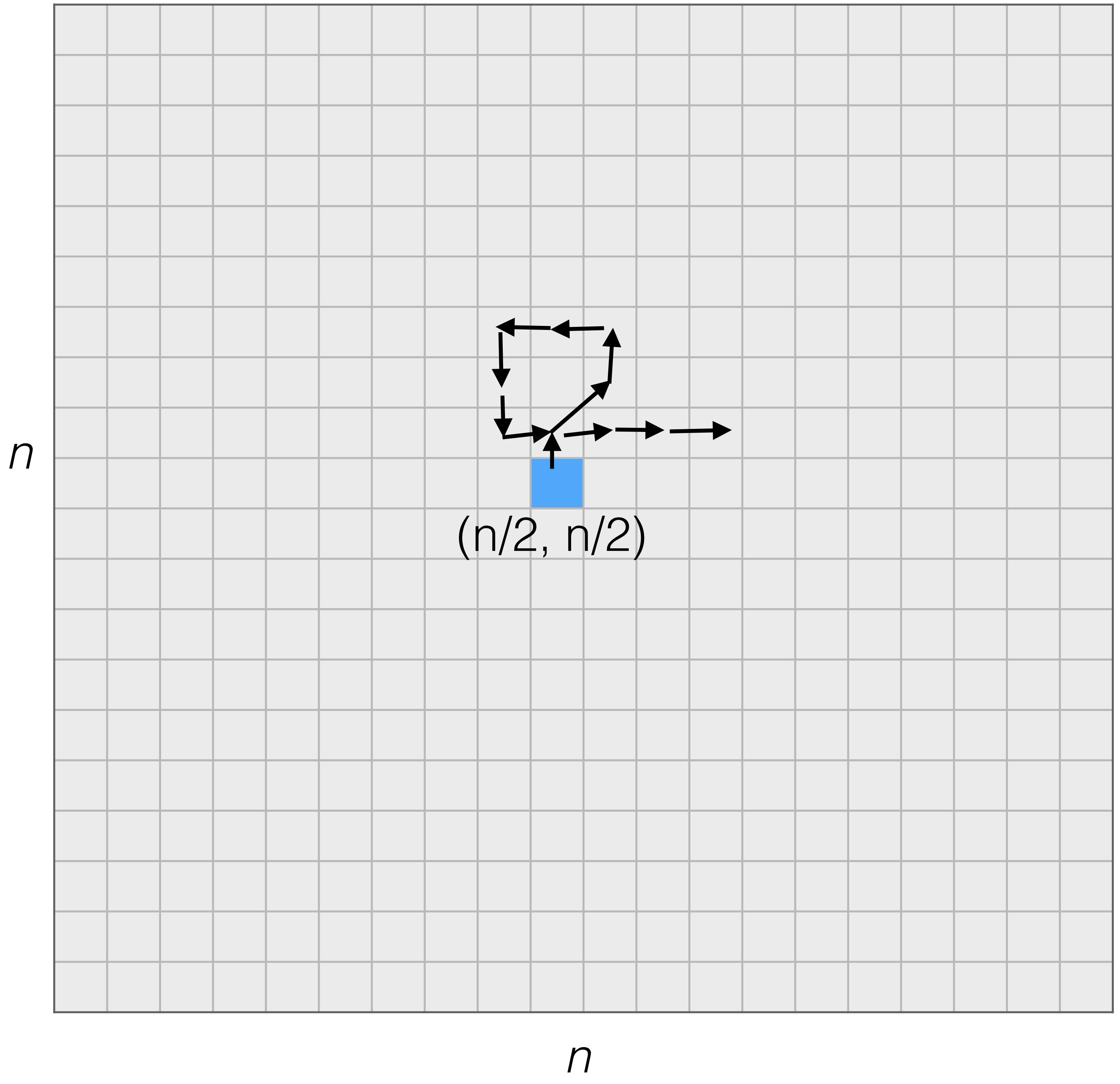
Nested loops: Printing a “Square”

```go
func printSquare(n int) {
    for i := 1; i <= n; i=i+1 {
        for j := 1; j <= n; j=j+1 {
            fmt.Print("#")
        }
        fmt.Println("")
    }
}
```

```
carlk$ go run square.go
##########
##########
##########
##########
##########
##########
##########
##########
##########
##########
```

Example: Random Walks

Simulate a random walk on an n-by-n chessboard



Example: Random Walks

Simulate a random walk on an n-by-n chessboard

```
func randDelta() int {
    return (rand.Int() % 3) - 1
}

func randomWalk(n, steps int) {
    var x, y = n/2, n/2
    fmt.Println(x,y)
    for i := 0; i < steps; i++ {
        var dx, dy int

        for dx == 0 && dy == 0 {
            dx = randDelta()
            for  x+dx < 0 || x+dx >= n {
                dx = randDelta()
            }

            dy = randDelta()
            for y+dy < 0 || y+dy >= n {
                dy = randDelta()
            }
        }
        x += dx
        y += dy
        fmt.Println(x,y)
    }
}
```

rand.Int() returns a random non-negative integer.

Must put
import “math/rand”
at top of your program.

Loop to make sure we move.

Loop to keep position within [0, n) x [0, n)

Note the code duplicating the test for an in-field coordinate.

This isn’t very good.

Better to break this out into a function.

```
x y
5 5
4 5
3 4
2 5
3 4
4 5
5 6
4 5
3 4
4 4
5 4
4 5
4 6
4 5
4 6
5 7
6 8
5 8
5 7
6 6
```

New Version With Better Functions

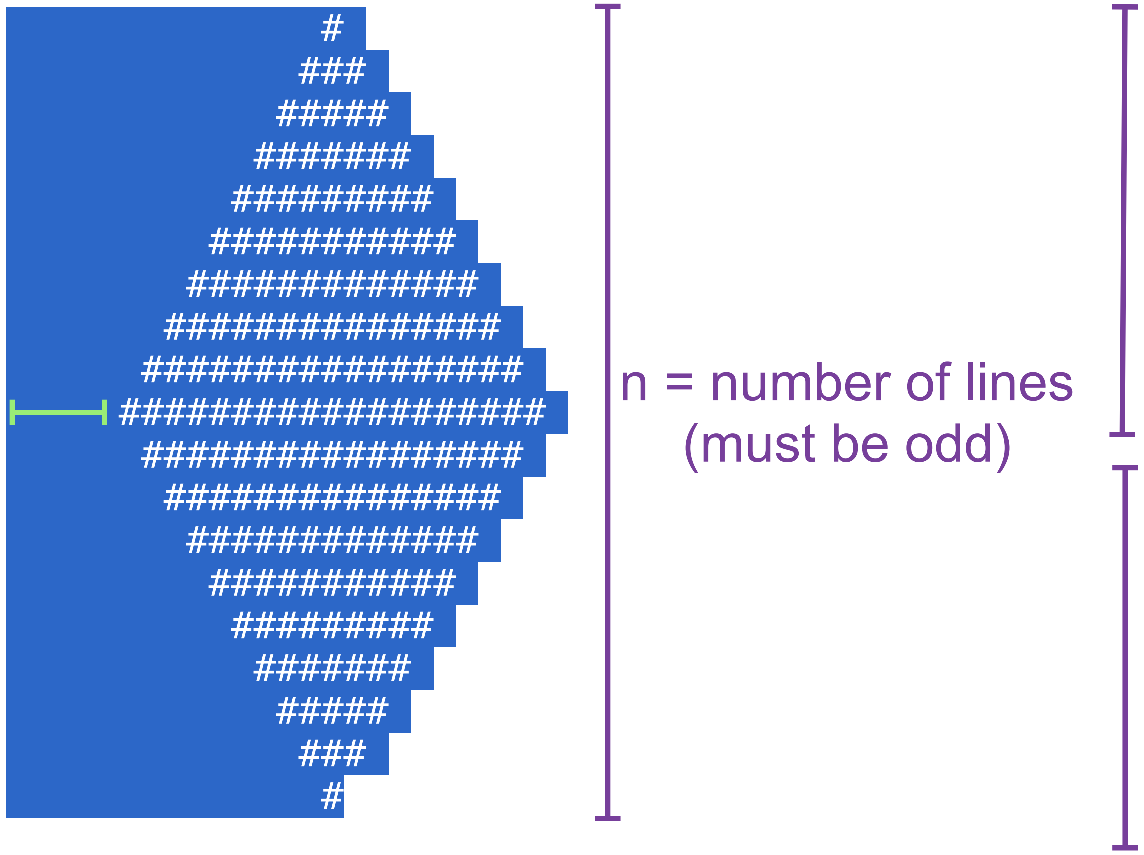
```
func randDelta() int {
    return (rand.Int() % 3) - 1
}

func inField(coord, n int) bool {
    return coord >= 0 && coord < n
}

func randStep(x,y,n int) (nx int, ny int) {
    nx, ny = x, y
    for (nx == x && ny == y) || !inField(nx,n) || !inField(ny,n) {
       nx = x+randDelta()
       ny = y+randDelta()
    }
    return
}

func randomWalk(n, steps int) {
    var x, y = n/2, n/2
    fmt.Println(x,y)
    for i := 0; i < steps; i++ {
        x,y = randStep(x,y,n)
        fmt.Println(x,y)
    }
}
```

This version is:

- clearer
- more flexible — perhaps we can use randStep() someplace else.
- Slightly shorter (25 vs. 26 lines)

Example: Print a Diamond

```
func printDiamond(n, shift int)
```



```
              #
             ###
            #####
           #######
          #########
         ###########
        #############
       ###############
      #################
     ###################
      #################
       ###############
        #############
         ###########
          #########
           #######
            #####
             ###
              #
```

shift = number of characters to shift diamond right

n = number of lines (must be odd)

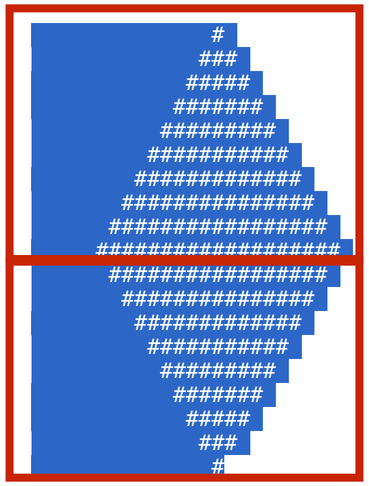
$\lceil n/2 \rceil$ ceil = largest integer ≤ n / 2

$\lfloor n/2 \rfloor$ floor = smallest integer ≥ n / 2

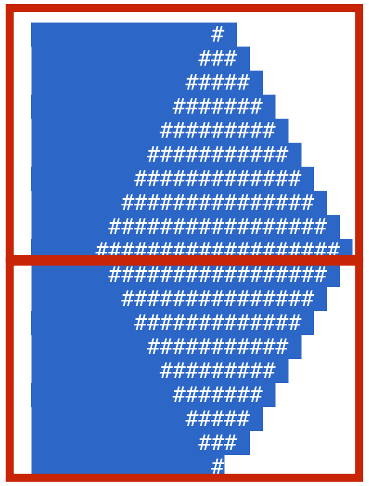
```
printDiamond(19,5)
```

Break into two subproblems:

```
printTriangle(n, shift int)
printInvertedTriangle(n, shift int)
```



Example: printDiamond



```
         #
        ###
       #####
      #######
     #########
    ###########
   #############
  ###############
 #################
###################
 #################
  ###############
   #############
    ###########
     #########
      #######
       #####
        ###
         #
```

Break into two subproblems:

```
    printTriangle(n, shift int)
    printInvertedTriangle(n, shift int)
```

```
func printDiamond(n, shift int) {
    if n % 2 == 0 {
        fmt.Println("Error! n must be odd; it's", n)
    } else {
        printTriangle(n / 2 + 1, shift)
        printInvertedTriangle(n/2, shift+1)
    }
}
```

Check that the parameters are valid. This is good practice.

Print top triangle.

Print bottom triangle.

Since *n* is odd:

$$\lceil n/2 \rceil = n/2 + 1$$
$$\lfloor n/2 \rfloor = n/2$$

What's going on here?
Since n is an integer variable and 2 is an integer
the code `n / 2` does ***integer*** division and rounds down.

The bottom triangle is slightly shorter and shifted to the right by 1 extra space.

Top-Down Program Design

- We "used" the `printTriangle()` and `printInvertedTriangle()` functions in our thinking before we wrote them.

- We know what they are supposed to do, so we could use them to write `printDiamond()` even before we implemented them.

- In a sense, it doesn't matter *how* `printTriangle()` and `printInvertedTriangle()` are implemented: if they do what they are supposed to do, everything will work.

- It's only their ***interface*** to the rest of the program that matters.

- This is top-down design, and it's often a very good way to approach writing programs:

  1. start by breaking down your task into subproblems.

  2. write a solution to the top-most subproblem using functions for other subproblems that you will write later.

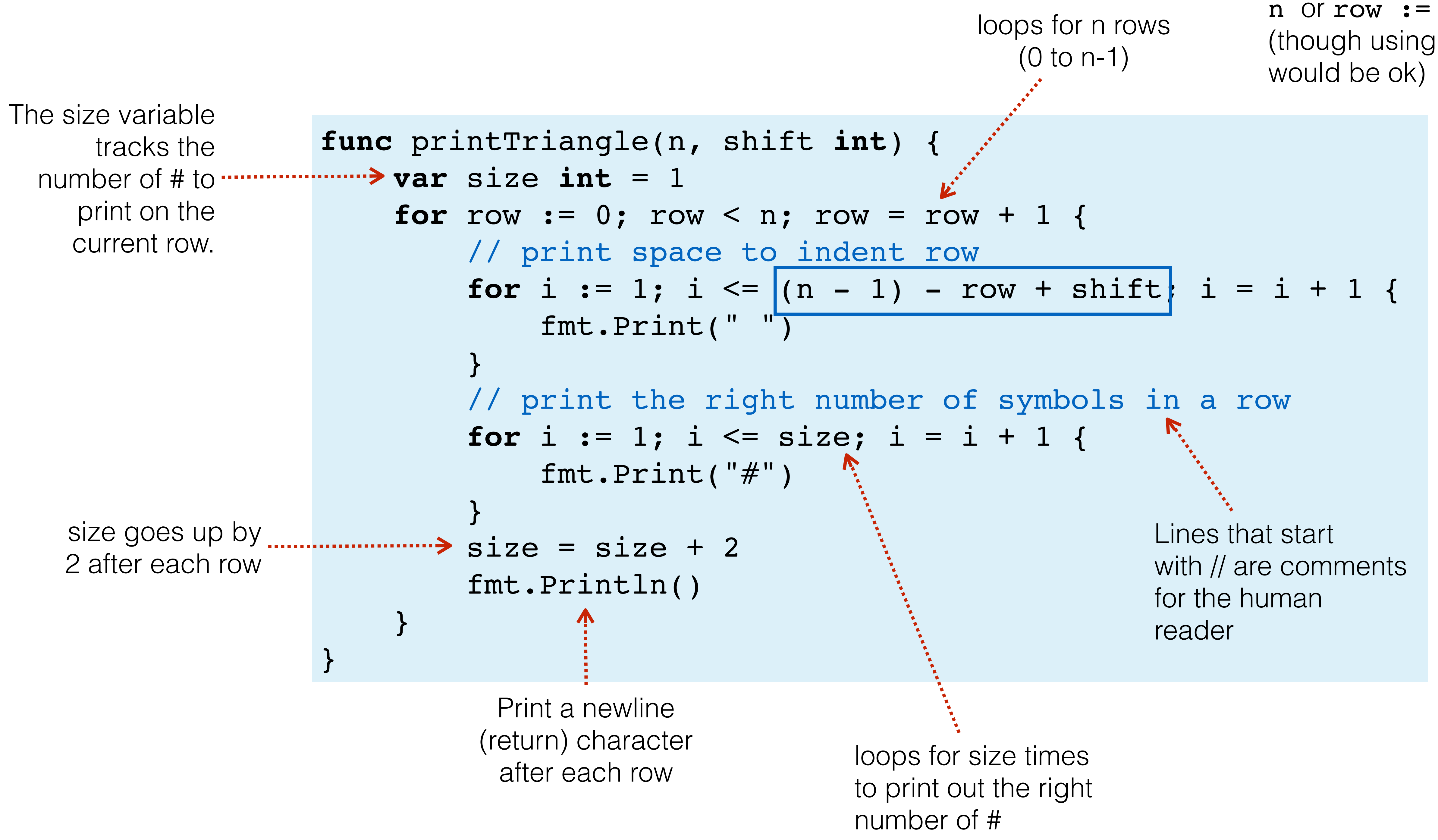
  3. then repeat by writing solutions to those subproblems, possibly breaking *them* up into subproblems.

Good Programming:

Break big problems into small functions with good interfaces.

printTriangle(n,shift)

Tip: watch out for “off-by-one” errors: e.g. using `row <= n` or `row := 1` (though using both would be ok)



loops for n rows
(0 to n-1)

The size variable tracks the number of # to print on the current row.

```
func printTriangle(n, shift int) {
    var size int = 1
    for row := 0; row < n; row = row + 1 {
        // print space to indent row
        for i := 1; i <= (n - 1) - row + shift; i = i + 1 {
            fmt.Print(" ")
        }
        // print the right number of symbols in a row
        for i := 1; i <= size; i = i + 1 {
            fmt.Print("#")
        }
        size = size + 2
        fmt.Println()
    }
}
```

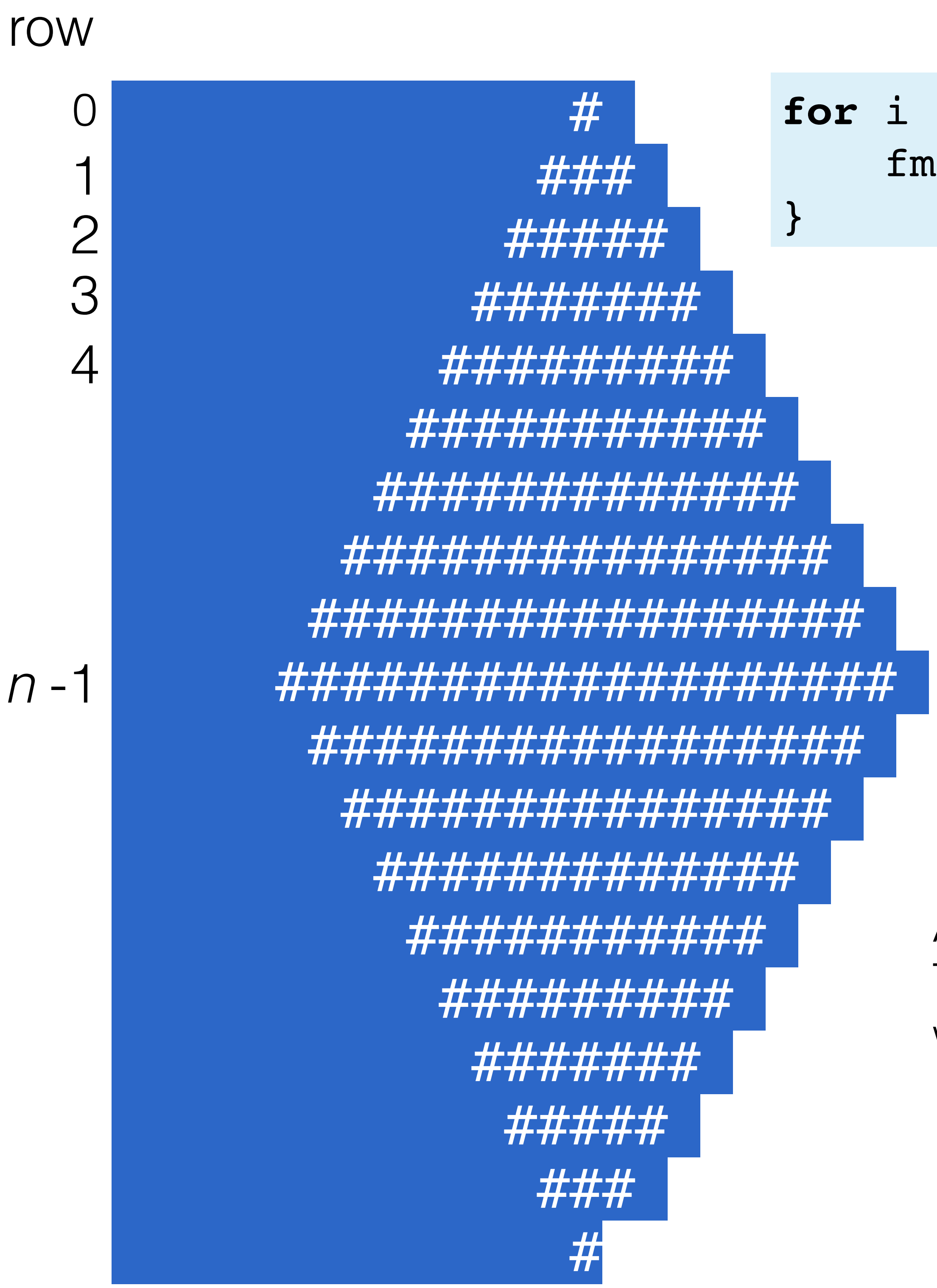
size goes up by 2 after each row

Lines that start with // are comments for the human reader

Print a newline (return) character after each row

loops for size times to print out the right number of #

Why n - row - 1 + shift?



```
         #
        ###
       #####
      #######
     #########
    ###########
   #############
  ###############
 #################
###################
 #################
  ###############
   #############
    ###########
     #########
      #######
       #####
        ###
         #
```

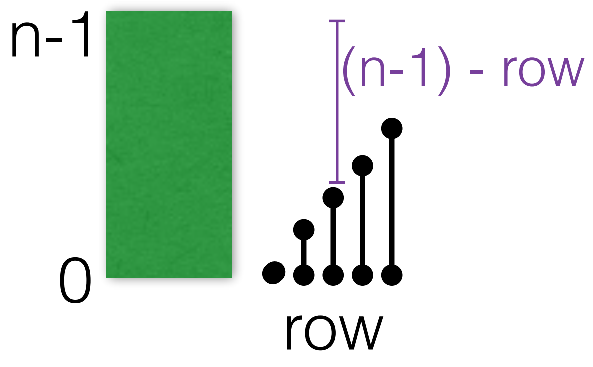
```
for i := 1; i <= (n - 1) - row + shift; i = i + 1 {
    fmt.Print(" ")
}
```

when row = n-3, loop should execute 2 + shift times

when row = n-2, loop should execute 1 + shift times

when row = n-1, loop should execute shift times

At each row, one fewer space should be written.
The last row (numbered n-1) should have shift spaces written.



printInvertedTriangle(n,shift)

size starts at the size of the top-most row, which has 2n - 1 symbols in it.

In first iteration of the row loop, row == n, so n - row = 0, and this loop iterates shift times

```
func printInvertedTriangle(n, shift int) {
    var size int = 2*n - 1
    // Note: this loop counts down
    for row := n; row > 0; row = row - 1 {
        for i := 1; i <= n - row + shift; i = i + 1 {
            fmt.Print(" ")
        }
        // print the right number of symbols in a row
        for i := 1; i <= size; i = i + 1 {
            fmt.Print("#")
        }

        size = size - 2
        fmt.Println()
    }
}
```

Complete Code for Diamond Example

```
func printTriangle(n, shift int) {
    var size int = 1
    for row := 0; row < n; row = row + 1 {
        // print space to indent row
        for i := 1; i <= n - row - 1 + shift; i = i + 1 {
            fmt.Print(" ")
        }
        // print the right number of symbols in a row
        for i := 1; i <= size; i = i + 1 {
            fmt.Print("#")
        }
        size = size + 2
        fmt.Println()
    }
}

func printInvertedTriangle(n, shift int) {
    var size int = 2*n - 1
    // Note: this loop counts down
    for row := n; row > 0; row = row - 1 {
        for i := 1; i <= n - row + shift; i = i + 1 {
            fmt.Print(" ")
        }
        // print the right number of symbols in a row
        for i := 1; i <= size; i = i + 1 {
            fmt.Print("#")
        }
        size = size - 2
        fmt.Println()
    }
}

func printDiamond(n, shift int) {
    if n % 2 == 0 {
        fmt.Println("Error! n must be odd; it's", n)
    } else {
        printTriangle(n / 2 + 1, shift)
        printInvertedTriangle(n/2, shift+1)
    }
}
```

Nested statements are indented for clarity

Comments are added to make code more readable

(don’t overdo comments though!)

A worse way to write printDiamond()

Bug! In fact, there is a subtle bug here:

```
func badPrintDiamond(n, shift int) {
    if n % 2 == 0 {
        fmt.Println("Error! n must be odd; it's", n)
    } else {
        var size int = 1
        for row := 0; row < n/2+1; row = row + 1 {
            // print space to indent row
            for i := 1; i <= (n/2+1) - row - 1 + shift; i = i + 1 {
                fmt.Print(" ")
            }
            // print the right number of symbols in a row
            for i := 1; i <= size; i = i + 1 {
                fmt.Print("#")
            }
            size = size + 2
            fmt.Println()
        }

        size = n - 1
        for row := (n/2); row > 0; row = row - 1 {
            for i := 1; i <= (n/2) - row + shift+1; i = i + 1 {
                fmt.Print(" ")
            }
            // print the right number of symbols in a row
            for i := 1; i <= size; i = i + 1 {
                fmt.Print("#")
            }
            size = size - 2
            fmt.Println()
        }
    }
}
```

Must understand the entire function before you really know what it does.
Bugs in top part affect execution of bottom part (what if you reassigned n accidentally someplace?)

Summary

- Conditionals let you choose which code to execute based on Boolean expressions
- Go has two types of conditionals: **if…else** and **switch.**
- Loops execute a set of statements repeatedly while a Boolean expression is true and stop when it becomes false.
- Go has only one type of loop: **for**
- Along with functions and variables, these constructs form the basis of all programs.