CS201 - PL'S

Control Flow - 01

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Expression evaluation

What is the value of the variable i after executing the following code (in either Java or C)?

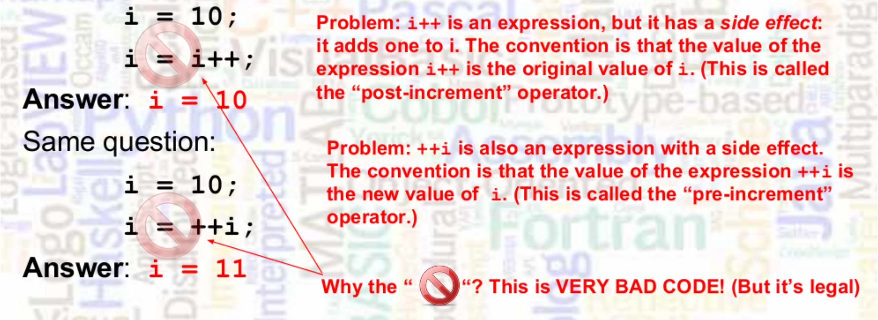
```
i = 10;
i = i++;
```

Same Question

```
i = 10;
i = ++i;
```

Expression Evaluation

Sequential execution–expression evaluation:



```
i = 10;
i = i++;
```

Answer: i = 10

Same question:

```
i = 10;
i = ++i;
```

Answer: i = 11

Problem: `i++` is an expression, but it has a *side effect*: it adds one to i. The convention is that the value of the expression `i++` is the original value of `i`. (This is called the “post-increment” operator.)

Problem: `++i` is also an expression with a side effect. The convention is that the value of the expression `++i` is the new value of `i`. (This is called the “pre-increment” operator.)

Why the “ 🚫 ”? This is VERY BAD CODE! (But it’s legal)

Expression Evaluation

```
int i=6, j=3, k=2;
int m = i/j*k;
```

So since `6/6 = 1, m = 1`, right?

Problem: / and * have equal precedence and they are left-associative: `i/j*k = (i/j)*k = (6/3)*2 = 4`.

Assignment Operators in Java and C

- The assignment operator “=” produces a value, just like other operators.
- The value of the expression “i = 10” is 10.
- This is a right-associative operator:
- “i = j = k = 10” means “i = (j = (k = 10))” and has the effect of setting all three variables to the same value, 10.
- In C, this can cause serious program bugs!

The following is legal in C:

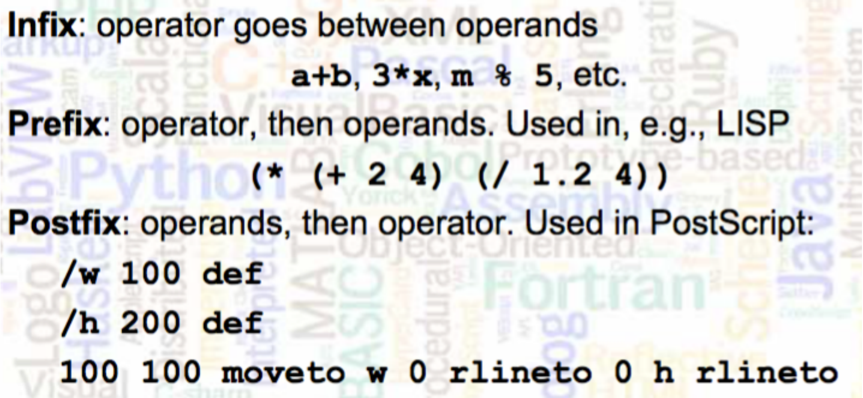
```
i = 0; if (i = 10) printf("i is 10");
```

The effect is to assign 10 to the variable i, then see if the resulting value (namely 10) is non-zero (in C, non-zero values represent “true”). This will always evaluate to true!

The programmer probably meant to write:

```
if (i == 10)
printf(``i is 10'');
```

Operators



Infix: operator goes between operands

a+b, **3*x**, **m % 5**, etc.

Prefix: operator, then operands. Used in, e.g., LISP

```
(* (+ 2 4) (/ 1.2 4))
```

Postfix: operands, then operator. Used in PostScript:

```
/w 100 def
/h 200 def
100 100 moveto w 0 rlineto 0 h rlineto
```

A Very Unusual Operator: ?

- Most operators are either binary $(+, -, *, <, ==, \&\&, etc.)$ or unary ("plus sign" +, "minus sign" -, ++, !, etc.).
- However, C and Java also have a ternary operator (takes 3 arguments).

Conditional operator "?"

```
boolean-expression ?  expression1 :
expression2
```

- The `boolean-expression` is evaluated. If it is true, the value is `expression1`, otherwise it is `expression2`.
- It has very low precedence, just above "assig
For example: $5 < 10?70 : -3$ is 70, while $5 > 10?70 : -3$ is -3

Evaluate these Java expressions

```
int i = 10;
int a,b,c,d,e;
a = b = c = ++i; // value1: _____
i = a==b ?20:30; // value2: _____
! (10==20) && 5 < 3 || 2 < 1  // value3:____
i = 0;
d = (d=++i)+d; // value4:_____
i = 0;
e = e+(e=++i); // value5:_____
```

Many Other Operators

Bitwise Operators

- $10|7 = 15$ (bitwise “or”)
- $10\&7 = 2$ (bitwise “and”)
- $10 << 3 = 80$ (left shift)
- $10 >> 1 = 5$ (right shift)

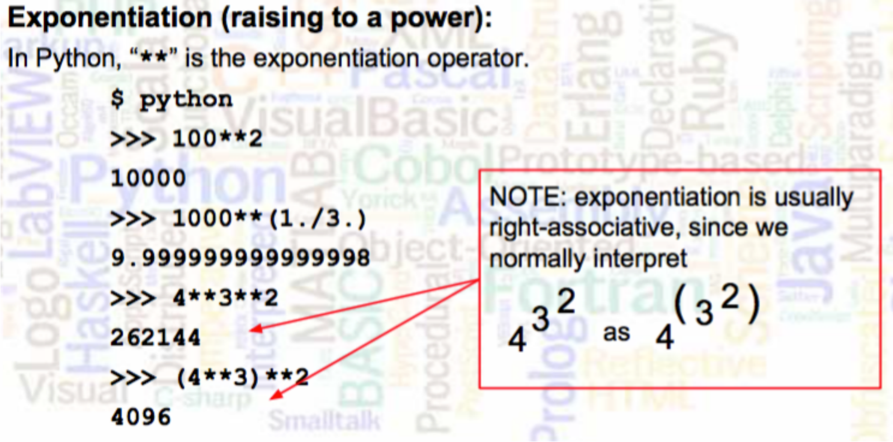
String operators:

- “Hello” + “world”

Referencing/dereferencing operators (C):

- $\&, *, \rightarrow$

Operators in Other Language



Exponentiation (raising to a power):

In Python, "**" is the exponentiation operator.

```
$ python
>>> 100**2
10000
>>> 1000**(1./3.)
9.9999999999999998
>>> 4**3**2
262144
>>> (4**3)**2
4096
```

NOTE: exponentiation is usually right-associative, since we normally interpret

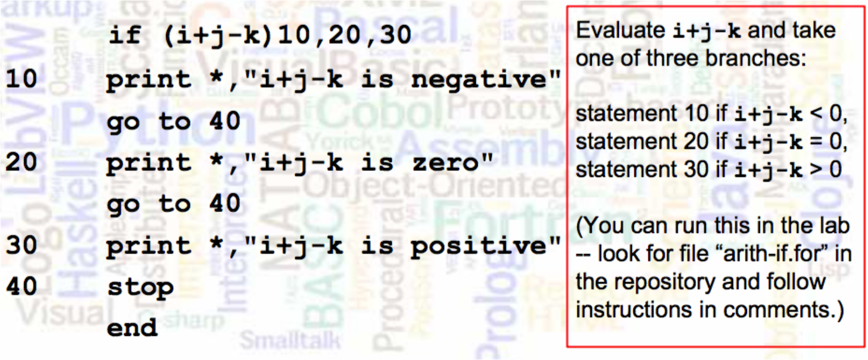
$4^{3^{2}}$ as $4^{(3^{2})}$

Conditional Branches

Familiar to most novice programmers:

- “if” and “if-else” statements “switch” statements
- *Basic idea*: `if (condition) then ... else ...`
- It wasn’t always quite this easy, though

Old FORTRAN Days



```
      if (i+j-k)10,20,30
10    print *,"i+j-k is negative"
      go to 40
20    print *,"i+j-k is zero"
      go to 40
30    print *,"i+j-k is positive"
40    stop
      end
```

Evaluate **`i+j-k`** and take one of three branches:

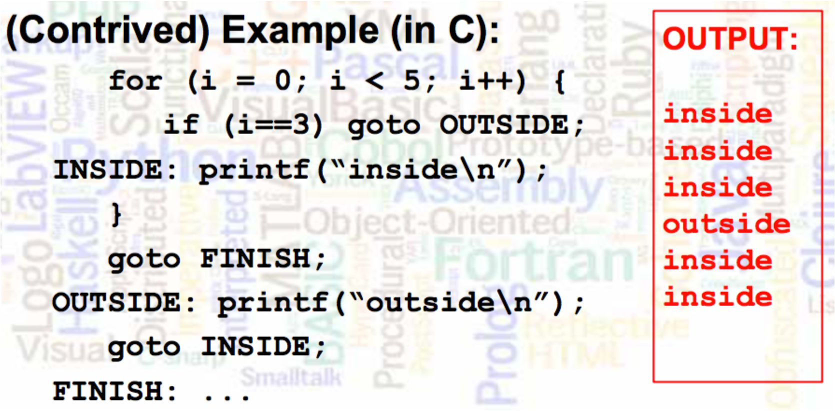
statement 10 if **`i+j-k`** < 0,
statement 20 if **`i+j-k`** = 0,
statement 30 if **`i+j-k`** > 0

(You can run this in the lab -- look for file “arith-if.for” in the repository and follow instructions in comments.)

The “go to” Statement

- “go to” is an UNCONDITIONAL branch.
- Most early programming languages had ”go to” statements.
- Later languages like C also adopted them.
- But, they were easy to misuse.

The “go to” Statement



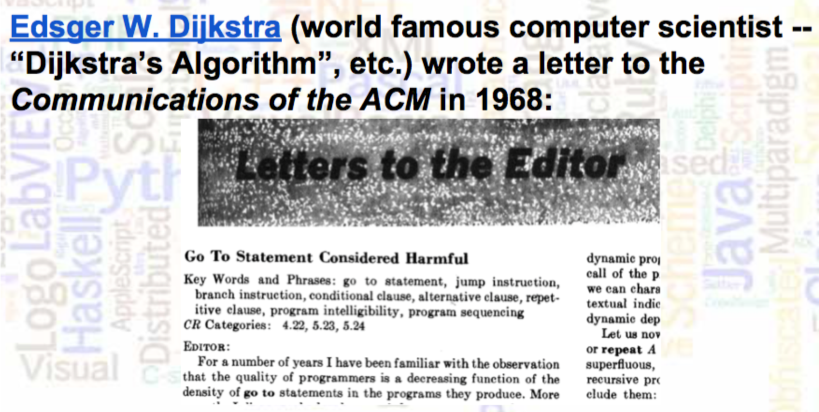
(Contrived) Example (in C):

```
    for (i = 0; i < 5; i++) {
          if (i==3) goto OUTSIDE;
INSIDE: printf(“inside\n”);
    }
    goto FINISH;
OUTSIDE: printf(“outside\n”);
    goto INSIDE;
FINISH: ...
```

OUTPUT:

```
inside
inside
inside
outside
inside
inside
```

The “go to” Statement



Edsger W. Dijkstra (world famous computer scientist -- “Dijkstra’s Algorithm”, etc.) wrote a letter to the *Communications of the ACM* in 1968:

Letters to the Editor

Go To Statement Considered Harmful

Key Words and Phrases: go to statement, jump instruction, branch instruction, conditional clause, alternative clause, repetitive clause, program intelligibility, program sequencing
CR Categories: 4.22, 5.23, 5.24

EDITOR:

For a number of years I have been familiar with the observation that the quality of programmers is a decreasing function of the density of **go to** statements in the programs they produce. More

dynamic pro
call of the p
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Let us nov
or **repeat** *A*
superfluous,
recursive pr
clude them:

The “go to” Statement

But why?

- We can “break out of scope” with a goto (the for-loop block might have its own local variables)
- We can write incomprehensible code (“spaghetti code”)

IN-CLASS EXERCISE: write some spaghetti code - get it out of your system!

Reading Assignment

PLP Chapter 06 [6.1.1 - 6.1.4]

Questions

Do you have any questions from this class discussion?