Week 4: If statements and boolean expressions

Gaddis: 4.1-4.9

CS 1428
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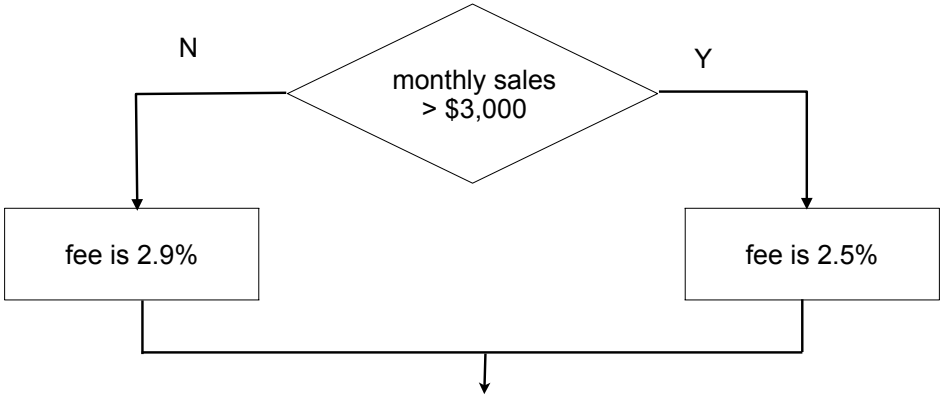
Straight-line code

- So far all of our programs have followed this basic format:
  - Input some values
  - Do some computations
  - Output the results
- The statements are executed in a sequence, first to last.

Decisions

- Sometimes we want to be able to decide which of two statements to execute:



Relational Expressions

- Making decisions require being able to ask “Yes” or “No” questions.
- Relational expressions evaluate to **true** or **false**.
- Also called:
  - logical expressions
  - conditional expressions
  - boolean expressions

Relational Expressions

- Boolean literals:

```
true
false
```

`true` evaluates to true

- Boolean variables

```
bool isPositive = true;
bool found = false;
```

`isPositive` evaluates to true
`found` evaluates to false

4.1 Relational Operators

- Binary operators used to compare expressions:
  - `<` Less than
  - `<=` Less than or equal to
  - `>` Greater than
  - `>=` Greater than or equal to
  - `==` Equals (note: do not use =) !!
  - `!=` Not Equals

Relational Expressions

- Examples:

```
int x=6;
int y=10;

a. x == 5          evaluates to ___false___
b. 7 <= x + 2      evaluates to _____
c. y – 3 > x       evaluates to _____
d. x != y          evaluates to _____
d. true            evaluates to ___true____
```

- Can assign relational expressions to variables:

```
bool isPositive;
int x;
cin >> x;
isPositive = x > 0;
```

if the user types: 25
`isPositive` evaluates to _____

Relational Operator Precedence

- Relational operators are LOWER than arithmetic operators:

```
int x, y;

...  x < y -10 ...       // minus happens first
...  x * 5 >= y + 10 ... // mult, then plus, then >=
```

- Relational operators are HIGHER than assignment:

```
int x, y;
...
bool t1 = x > 7;            // > then =
bool t2 = x * 5 >= y + 10;  // *, +, >=, =
```

4.4 if-else statement

- if-else statement is used to make decisions

```
if (expression)
   statement1
else
   statement2
```

- `expression` is evaluated
  - If it is true, then `statement1` is executed. (`statement2` is skipped).
  - If it is false, then `statement2` is executed (`statement1` is skipped).

if-else example

```
double rate;
double monthlySales;

cout << "Enter monthly sales last month: " ;
cin >> monthlySales;

if (monthlySales > 3000)
   rate = .025;
else
   rate = .029;

double price;
cout << "Enter selling price of item: " ;
cin >> price;
double commission = (price + 3.99) * rate;
cout << "Commission: $" << commission << endl;
```

```
Enter monthly sales last month: 3025
Enter selling price of item: 100
Commission: $2.59975
```


if-else structure

Notice:

```
if (monthlySales > 3000)
   rate = .025;
else
   rate = .029;
```

- relational expression is in parentheses
- NO semi-colon after expression, nor the else
- Good style: indent the statements!!
- The semi-colons belong to the statements, not to the if-else

4.3 The block statement

- a block (or a compound statement) is a set of statements inside braces:

```
{  int x;
   cout << “Enter a value for x: “ << endl;
   cin >> x;
   cout << “Thank you.” << endl;
}
```

- This groups several statements into a single statement.
- This allows us to use multiple statements when by rule only one is allowed.

if-else with blocks

- We can use blocks to put more than one statement in the branches of the if-else:

```
int number;
cout << "Enter a number" << endl;
cin >> number;

if (number % 2 == 0)
{
   number = number / 2;
   cout << "Even";
}
else
{
   number = (number – 1) / 2;
   cout << "Odd";
}
```


4.2 if statement

- The else part is optional:

```
if (expression)
   statement
```

- `expression` is evaluated
  - If it is true, then `statement` is executed.
  - If it is false, then `statement` is skipped

if statement example

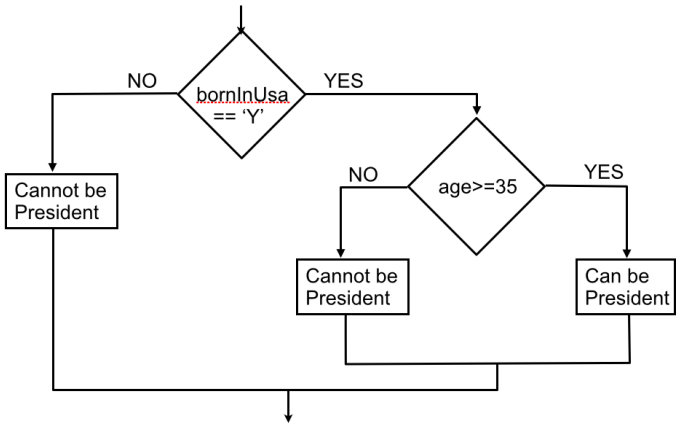
- Example: input validation

```
cout << "Enter a positive number: ";
cin >> x;
if (x < 0)
{
   cout << "That number is negative. "
        << "Please enter a positive number: ";
   cin >> x;
}

//do something with x here
```


4.5 Nested if statements

- if-else is a statement. It can occur as a branch of an if-else statement.



Nested if statements

- if-else is a statement. It can occur as a branch of an if-else statement.

```
char bornInUSA;
int age;
cout << "Were you born in the USA (Y/N)?: " ;
cin >> bornInUSA;
cout << "Please enter your age: ";
cin >> age;

if (bornInUSA == 'Y')
   if (age >= 35)
      cout << "You qualify to run for President\n";
   else
      cout << "You are too young to run for President\n";
else
   cout << "You must have been born in the US in order "
        << "to run for President" << endl;
```


Nested if statements

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else
   cout << "You must have been born in the US in order "
        << "to run for President" << endl;
```


Common nested if pattern

- Determine letter grade from test score:

If we are in this else branch, what do we know about the value of testScore?

```
if (testScore < 60)
   grade = 'F';
else {
     if (testScore < 70)
        grade = 'D';
     else {
          if (testScore < 80)
             grade = 'C';
          else {
               if (testScore < 90)
                  grade = 'B';
               else
                  grade = 'A';
               }
          }
     }
```

- Note the braces are actually optional here!

4.6 The if-else if Statement

- Not really a different statement, just a different way of indenting the nested if statement from the previous slide:

```
if (testScore < 60)
   grade = 'F';
else if (testScore < 70)
   grade = 'D';
else if (testScore < 80)
   grade = 'C';
else if (testScore < 90)
   grade = 'B';
else
   grade = 'A';
```

- removed braces, put "if (…)" on previous line
- eliminated nested indentation.

4.8 Logical Operators

- Used to create relational expressions from other relational expressions:
  - **&&** AND (binary)

    a && b is true only when both a and b are true
  - **||** OR (binary)

    a || b is true whenever either a or b is true
  - **!** NOT (unary)

    !a is true when a is false

Logical Operators

- Examples

```
int x=6;
int y=10;

a. x == 5 && y <= 3
b. x > 0 && x < 10
c. x == 10 || y == 10
d. x == 10 || x == 11
e. !(x > 0)
f. !(x > 6 || y == 10)

bool flag;
flag = (x > 0 && x < 25);
g. !flag
h. flag || x < 100
```

false && false is false
true && true is true
false || true is true
___ || ___ is ____
!true is _____
!(false || true) is ____

Logical Operator Precedence

- ! is higher than most operators, so use parentheses:

```
int x;

...  !(x < 0 && x > -10) ... // <, >, &&, !
```

- && is higher than ||

```
int x, y;
bool flag;

... flag || x * 5 >= y + 10 && x == 5

   // which op is first? second? etc?
```

- && and || are lower than arithmetic+relational operators: parens not usually needed

4.9 Checking Numeric Ranges

- We want to know if x is in the range from 1 to 10 (inclusive)

```
a. if (1 <= x <= 10)          //as in math class
      cout << "YES" << endl;

   //WRONG: ((1<=x) <=10)  (assume x is -5)
   //     => ( false <= 10)
   //     => ( 0 < = 10 ) is true

b. if (1 <= x && x <= 10)
      cout << "YES" << endl;

   -check: x=0? (1<=0 && 0<=10) => false && true

   -check: x=5? (1<=5 && 5<=10) => true && true

   -check: x=100? (1<=100 && 100<=10) => ??
```