Principles of Computer Science I

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CSC 120 – Fall 2005
Lecture Unit 6 - Decisions

Lecture Outline

- Implementing decisions using if statements
- Grouping statements into blocks
- Comparing numbers, strings, and objects
- Using Boolean operators and variables

Making Decisions

- Computer programs often need to make decisions
  - Take different actions depending on some condition(s)
- Example: Can't withdraw more money than in account balance
  - "If amount-to-withdraw is less than available balance then deduct from balance; otherwise charge a penalty to the balance."
-

```
if ( amount <= balance )
   balance = balance - amount;
```


`if/else` Statement

- Does this work?

```
if ( amount <= balance )
   balance = balance - amount;
if ( amount > balance )
   balance = balance - OVERDRAFT_PENALTY;
```

- How about this?

```
if ( amount <= balance )
   balance = balance - amount;
else
   balance = balance - OVERDRAFT_PENALTY;
```


Types of Statements

- Simple
  - `balance = balance - amount;`
- Compound
  - `if ( amount <= balance ) balance = balance - amount;`
- Block
  - Groups multiple statements together
  - Can be used anywhere a single statement is used

```
{
   double newBalance = balance - amount;
   balance = newBalance;
}
```


Syntax: if Statement

if (*condition*) *statement*

if (*condition*) *statement1* **else** *statement2*

Purpose:
To execute a statement(s) depending on whether a condition is true or false

Syntax: Block Statement

```
{
   statement1
   statement2
   ...
}
```

Purpose:
To group several statements together to form a single statement

Brace Layout

- Doesn't matter to compiler – matters to human
- Two suggested styles – choose one and stick to it

```
if ( amount <= balance )
{
   double newBalance = balance - amount;
   balance = newBalance;
}
```

- ***or***

```
if ( amount <= balance ) {
   double newBalance = balance - amount;
   balance = newBalance;
}
```


Indentation

- Another very critical way to make programs readable for humans
- Use spaces instead of tab key
- 2, 3, or 4 spaces are best
- Tips
  - Always type the beginning and ending braces first, then fill in between
  - Put comment after closing brace to indicate what it matches

```
public class BankAccount {
. . .
public void withdraw( double amt )
{
if ( amt <= balance )
{
double newBal = balance - amt;
balance = newBal;
}
}    . . .
}
```

```
public class BankAccount
{
   . . .
   public void withdraw( double amt )
   {
      if ( amt <= balance )
      {
         double newBal = balance - amt;
         balance = newBal;
      } // end if
   } // end withdraw method
   . . .
} // end BankAccount class
```


Comparing Values

- *Relational* operators

Java	*Math Notation*	*Description*
>	>	Greater than
>=	≥	Greater than or equal
<	<	Less than
<=	≤	Less than or equal
==	=	Equal
!=	≠	Not equal

- == operator denotes equality testing

```
a = 5; // Assign 5 to a
if ( a == 5 ) . . . // Test whether a equals 5
```


Comparing Floating Point

```
double r = Math.sqrt( 2 );
double d = r * r -2;
if ( d == 0 )
   System.out.println( "sqrt(2)squared minus 2 is 0" );
else
   System.out.println( "sqrt(2)squared minus 2 is not 0 but " + d );
```

```
sqrt(2)squared minus 2 is not 0 but 4.440892098500626E-16
```

- Don't compare floating point numbers for (exact) equality ==
  - Doesn't work because of roundoff errors
- Instead, check if they are close enough (up to a desired threshold)

Comparing Floating Point (Correctly)

- Test whether (absolute value of) the difference between two number is close to 0
  - Threshold often referred to as ε – 'epsilon'

$$|x - y| \leq \varepsilon$$

- In Java:

```
final double EPSILON = 1E-14;
. . .
if ( Math.abs(x - y) <= EPSILON )
   // x is approximately equal to y
```

Comparing Strings

- Don't use `==` for strings either!

```
if (input == "Y") // WRONG!!!
```

- Use the `equals` method

```
if (input.equals("Y"))  . . .
```

- `==` tests identity; `equals` tests equal contents
  - Will see this again in 'Comparing Objects' slides
- To test equality ignoring upper/lowercase ('Y' or 'y')

```
if (input.equalsIgnoreCase("Y")) . . .
```


Comparing Order of Strings

- Use the `compareTo` method
  - `s.compareTo(t) < 0` means s comes before t
  - `s.compareTo(t) > 0` means s comes after t
  - `s.compareTo(t) == 0` means s and t are equal
- Java's 'dictionary' order is according to Unicode
  - 'car' comes before 'cargo'
  - All uppercase letters come before lowercase
    - 'Hello' comes before 'car'
  - Numbers come before letters
    - '1' comes before 'a'
  - See Appendix B in textbook

Comparing Objects

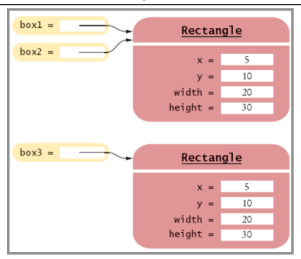
- Like strings, `==` tests identity; `equals` tests contents

```
Rectangle box1 = new Rectangle(5, 10, 20, 30);
Rectangle box2 = box1;
Rectangle box3 = new Rectangle(5, 10, 20, 30);
```

- `box1 != box3` but `box1.equals( box3 )`
- `box1 == box2`
- Warning: `equals` method must be defined properly by the class before you can use it

Object References

```
Rectangle box1 = new Rectangle(5, 10, 20, 30);
Rectangle box2 = box1;
Rectangle box3 = new Rectangle(5, 10, 20, 30);
```



Testing for `null`

- Object variable may be set to `null`
- Indicates 'no object'

```
String middleInitial = null; // Not set
if ( . . . )
   middleInitial = middleName.substring(0, 1);
```

- Can be used as a condition (use `==`):

```
if (middleInitial == null)
   System.out.println(firstName + " " + lastName);
else
   System.out.println(firstName + " " + middleInitial
                                + ". " + lastName);
```


Strings and `null`

- Empty string is `""`
  - Valid string of length 0
- `null` indicates a string variable does not refer to anything, not even an empty string
- Always test for `null` using `==` not the `equals` method

Conditions with Side Effects

- Avoid in `if` statements!
  - Bad programming practice
- Side effects: assignment, increment, decrement

```
if ( ( d = b * b - 4 * a *c ) >= 0 ) r = Math.sqrt( d );

if ( n-- > 0 ) . . .
```

- Can occasionally be useful to simplify loops
  - Next chapter

Multiple Alternatives

- Sequences of comparisons

```
if ( condition1 ) statement1;
else if ( condition2 ) statement2;
. . .
else statementN;
```

Earthquake.java
EarthquakeTester.java

- The first matching condition is executed
- Order matters!

```
if ( richter >= 0 )              // always passes
   r = "Generally not felt by people";
else if ( richter >= 3.5 )       // not tested
   r = "Felt by many people, no destruction. . .
```


if vs. if/else

- Consider carefully which one is appropriate to use

```
if ( richter >= 8.0 )
   r = "Most structures fall";
if ( richter >= 7.0 )
   r = "Many buildings destroyed";
if ( richter >= 6.0 )
   r = "Many buildings considerably damaged, some collapse";
if ( richter >= 4.5 )
   r = "Damage to poorly constructed buildings";
if ( richter >= 3.5 )
   r = "Felt by many people, no destruction";
if ( richter >= 0 )
   r = "Generally not felt by people";
return r;
```


Nested Branches

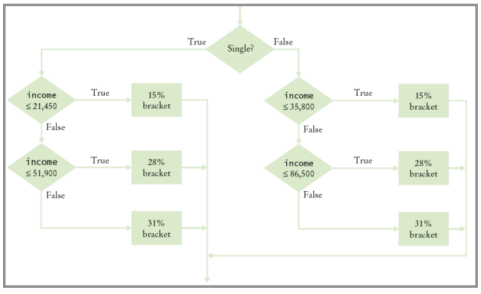
- One `if` statement inside another

```
if ( condition1 ) {
    if ( condition1A )
        statement1A;
    else
        statement1B;
} else
    statement2;
```


Example: Computing Taxes

If your filing status is single		If your filing status is married	
Tax Bracket	Percentage	Tax Bracket	Percentage
$0 … $21,450	**15%**	**$0 … $35,800**	**15%**
Amount over $21,451, up to $51,900	**28%**	**Amount over $35,800, up to $86,500**	**28%**
Amount over $51,900	**31%**	**Amount over $86,500**	**31%**

Taxes Flowchart



Tax Program

- *TaxReturn.java*
- *TaxReturnTester.java*
- Beware 'Dangling else': pg 210

25

Preparing Test Cases

- Test cases should achieve complete coverage of input possibilities
- Tax program
  - 2 filing possibilities
  - 3 tax brackets
  - = 6 possible combinations
- To test the program, select 6 valid inputs and at least 1 invalid input (negative income)

26

Selection Operator

```
condition  ?  value1  :  value2
```

- Combines *values* to yield another value depending on *condition*
  - `if` construct combines *statements*

```
if ( x >= 0 ) y = x; else y = -x;
y  =  x >= 0 ? x : -x;
```

27

`switch` Statement

- Replaces sequence of `if`/`else`/`else` comparing single integer value against constant alternatives

```
int digit;
. . .
if ( digit == 1 )
   System.out.print( "one" );
else if ( digit == 2 )
   System.out.print( "two" );
else if ( digit == 3 )
   System.out.print( "three" );
. . .
else if ( digit == 9 )
   System.out.print( "nine" );
else
   System.out.print( "error" );
```

```
switch ( digit ) {
     case 1: System.out.print( "one" );
             break;
     case 2: System.out.print( "two" );
             break;
     case 3: System.out.print( "three" );
             break;
     . . .
     case 9: System.out.print( "nine" );
             break;
     default: System.out.print( "error" );
              break;
}
```

28

`switch` Statement (cont.)

- Case values must be constants and must be integers, characters, or enumerated constants
  - Cannot be used with floating point, string, or objects
- Without `break` statements, execution 'falls through' to the next case until the end

29

The `boolean` Type

- George Boole (1815-1864): pioneer in the study of logic
- Value of an expression like `amount < 100` is either `true` or `false`
- **`boolean`** type: one of these two truth values
  - Sometimes referred to as 0 and 1

```
double amount = 0;
boolean b = amount < 1000;
System.out.println( b );
```

30

Boolean Operators

- Used to combine boolean expressions
  - `&&` — 'and'
  - `||` — 'or' (to type |, use 'shift' key + '\')
  - `!` — 'not'
  - Also called *logical operators*
- `if ( 0 < amount && amount < 1000 ) . . .`
  - Both conditions must be satisfied
- `if ( input.equals("S") || input.equals("M") ) . . .`
  - At least one of the conditions must be satisfied

Boolean Operators (cont.)

- `if ( !input.equals("S") ) . . .`
  - Inverts the condition – if input is *not* "S"
- Truth tables

A	B	A && B
True	True	True
True	False	False
False	*Any*	False

A	B	A||B
True	*Any*	True
False	True	True
False	False	False

A	!A
True	False
False	True

- Expressions can be simplified using rules of Boolean algebra - e.g. see Topic 6.5 (pg 218)

Boolean Operators: Lazy/Short-Circuit Evaluation

- && and || operators computed from left to right; stop evaluation as soon as truth value can be determined
  - 'and': if first condition is *false*, skips the second
  - 'or': if first condition is *true*, skips the second

```
if ( input != null  &&  Integer.parseInt( input ) > 0 ) . . .
```


Predicate Methods

- Methods that return `boolean` value

```
public class BankAccount {
   . . .
   public boolean isOverdrawn() {
      return balance < 0;
   }
```

- Can be used in conditions

```
if ( harrysChecking.isOverdrawn() ) . . .
```


Useful Predicate Methods

- Character class
  - `isDigit`
  - `isLetter`
  - `isUpperCase`
  - `isLowerCase`

```
if ( Character.isUpperCase( ch ) ) . . .
```

- Scanner class: `hasNextInt`, `hasNextDouble`

```
if (in.hasNextInt()) n = in.nextInt();
```


Boolean Variables

```
private boolean married;
```

- Can store a truth value, or the outcome of a condition expression
  - `married = input.equals( "M" );`
- Can be used in expressions
  - `if ( married ) . . . else . . .`
  - `if ( !married ) . . .`

Boolean Variables: 'Flags'

- Sometimes also called 'flags'
- Think carefully about names of variables
  - `maritalStatus` vs. `married`
- Don't write tests like this:
  - `if ( married == true ) . . . // Don't`
  - `if ( married == false ) . . . // Don't`
- Use this instead:
  - `if ( married ) . . .`
  - `if ( !married ) . . .`

37

Artificial Intelligence

- Serious research: mid-1950s
- Successes?
  - Chess
  - Theorem-proving
  - OCR
- Failures?
  - Translation
  - Grammar-checking
- Most 'AI' techniques don't actually imitate human thinking
- Ethical issues? . . .

38