More Selection

Executing Statements Selectively

Chap. 7
(Read §7.1-7.4 & Part of Picture:
Boolean Logic and Digital Design)

Review

We've seen that Java's if statement permits a statement to be executed selectively:

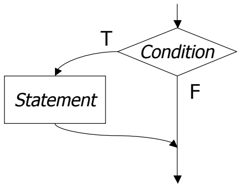
```
        if (Expression)
          Statement$_1$
      [ else
          Statement$_2$ ]
```

where expression is usually a boolean expression called a *condition*.
From this, the Java if statement can have three different forms:

The Simple if

The first form has no **`else`** or *Statement$_2$*, and is called the *simple if*:

```
if (Condition)
  Statement
```

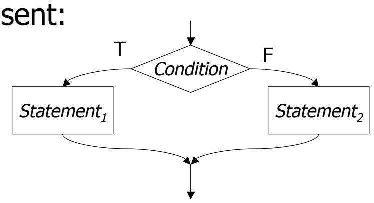


If *Condition* is true, *Statement* is executed; otherwise *Statement* is skipped.

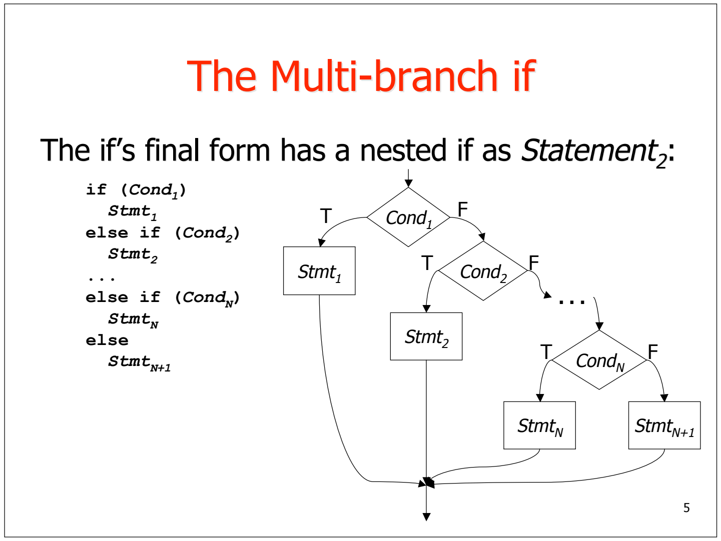
The Two-Branch if

In the second form of if, the **`else`** and *Statement$_2$* are present:

```
if (Condition)
  Statement$_1$
else
  Statement$_2$
```



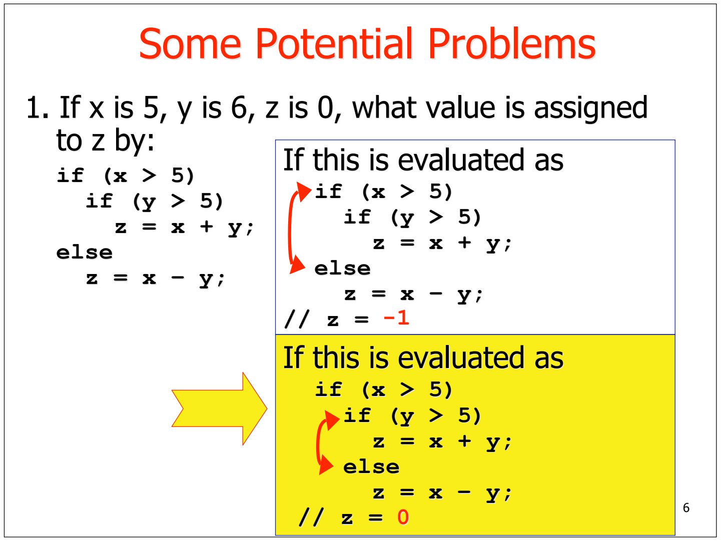
If *Condition* is true, *Statement$_1$* is executed and *Statement$_2$* is skipped; otherwise *Statement$_1$* is skipped and *Statement$_2$* is executed.



The Multi-branch if

The if's final form has a nested if as *Statement$_2$*:

```
if (Cond1)
   Stmt1
else if (Cond2)
   Stmt2
...
else if (CondN)
   StmtN
else
   StmtN+1
```



Some Potential Problems

1. If x is 5, y is 6, z is 0, what value is assigned to z by:

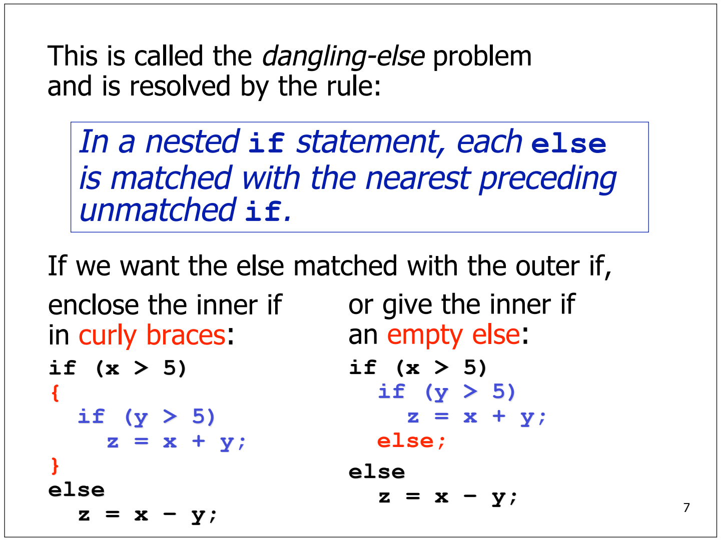
```
if (x > 5)
  if (y > 5)
    z = x + y;
else
  z = x - y;
```

If this is evaluated as

```
if (x > 5)
  if (y > 5)
    z = x + y;
else
  z = x - y;
// z = -1
```

If this is evaluated as

```
if (x > 5)
  if (y > 5)
    z = x + y;
  else
    z = x - y;
 // z = 0
```



This is called the *dangling-else* problem and is resolved by the rule:

In a nested **`if`** *statement, each* **`else`** *is matched with the nearest preceding unmatched* **`if`**.

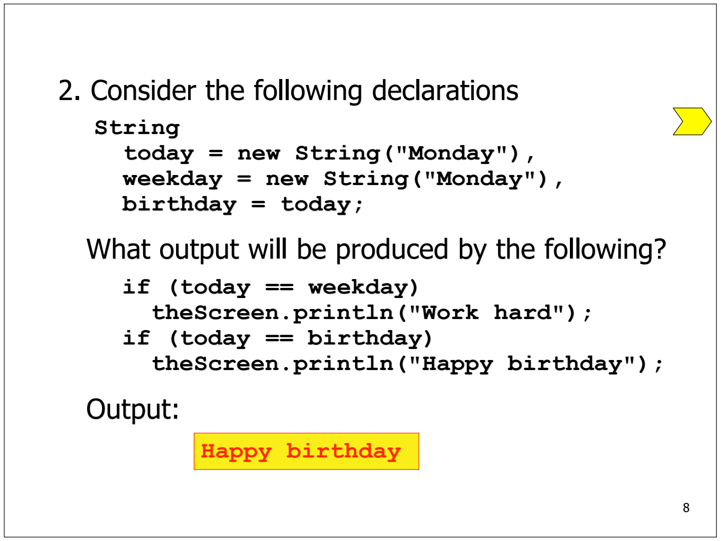
If we want the else matched with the outer if,

enclose the inner if in curly braces:

```
if (x > 5)
{
  if (y > 5)
    z = x + y;
}
else
  z = x - y;
```

or give the inner if an empty else:

```
if (x > 5)
  if (y > 5)
    z = x + y;
  else;
else
  z = x - y;
```



2. Consider the following declarations

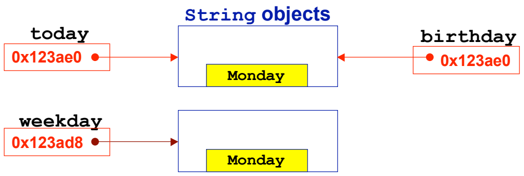
```
String
  today = new String("Monday"),
  weekday = new String("Monday"),
  birthday = today;
```

What output will be produced by the following?

```
if (today == weekday)
  theScreen.println("Work hard");
if (today == birthday)
  theScreen.println("Happy birthday");
```

Output:

```
Happy birthday
```



today == weekday? 0x123ae0 == 0x123ad8?
No

today == birthday? 0x123ae0 == 0x123ae0?
Yes

Relational operators compare addresses in handles, not the values of the objects they refer to.

Corollary: Classes should provide methods for comparing objects – e.g., String provides **equals()** and **equalsIgnoreCase()**, **compareTo()** and **compareToIgnoreCase()**.

```
if ( today.equals(weekday) )
  theScreen.println("Work hard");
if ( today.equals(birthday) )
  theScreen.println("Happy birthday");
```

Output:

```
Work hard
Happy birthday
```

Using Selection

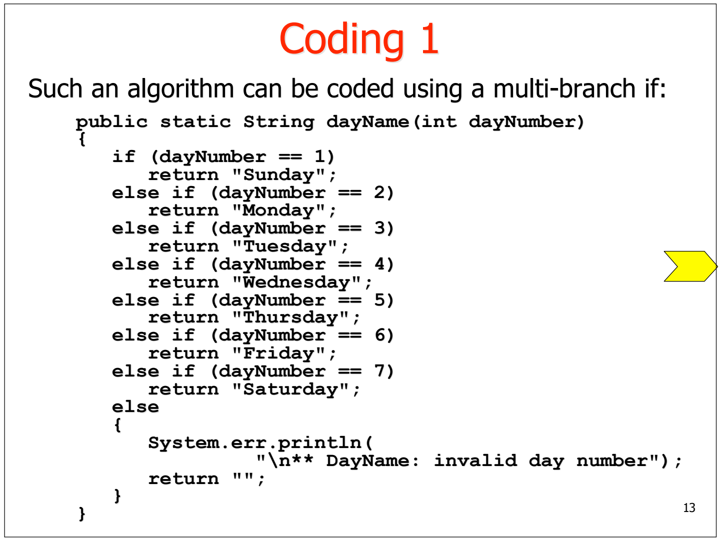
Selection is useful anytime you want to execute a statement under particular circumstances.

Example: Suppose we need a method that, given the number of a day of the week (1-7), computes its corresponding name (Sunday-Saturday)?

Algorithm

```
0. Receive dayNumber.

1. If dayNumber == 1:
         Return "Sunday".
   Else if dayNumber == 2:
         Return "Monday".
   Else if dayNumber == 3:
         Return "Tuesday".
   Else if dayNumber == 4:
         Return "Wednesday".
   Else if dayNumber == 5:
         Return "Thursday".
   Else if dayNumber == 6:
         Return "Friday".
   Else if dayNumber == 7:
         Return "Saturday".
   Else
         Display an error message, and return "".
```



Coding 1

Such an algorithm can be coded using a multi-branch if:

```
public static String dayName(int dayNumber)
{
   if (dayNumber == 1)
      return "Sunday";
   else if (dayNumber == 2)
      return "Monday";
   else if (dayNumber == 3)
      return "Tuesday";
   else if (dayNumber == 4)
      return "Wednesday";
   else if (dayNumber == 5)
      return "Thursday";
   else if (dayNumber == 6)
      return "Friday";
   else if (dayNumber == 7)
      return "Saturday";
   else
   {
      System.err.println(
               "\n** DayName: invalid day number");
      return "";
   }
}
```

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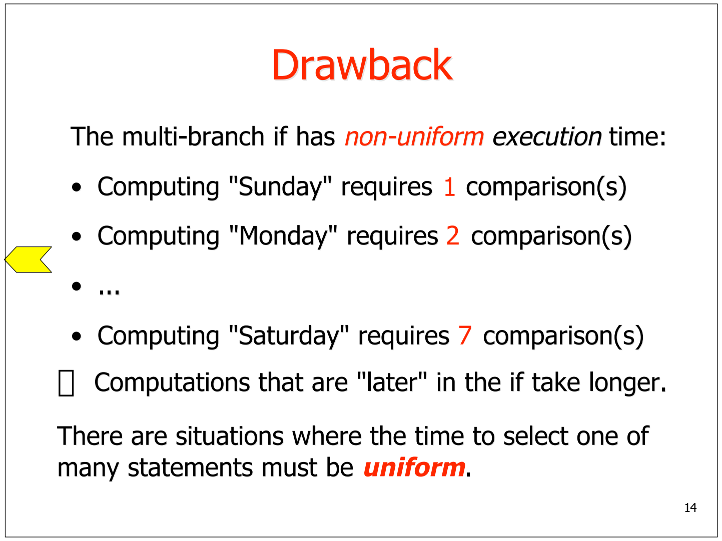

Drawback

The multi-branch if has *non-uniform execution* time:

- Computing "Sunday" requires 1 comparison(s)
- Computing "Monday" requires 2 comparison(s)
- ...
- Computing "Saturday" requires 7 comparison(s)

□ Computations that are "later" in the if take longer.

There are situations where the time to select one of many statements must be ***uniform***.

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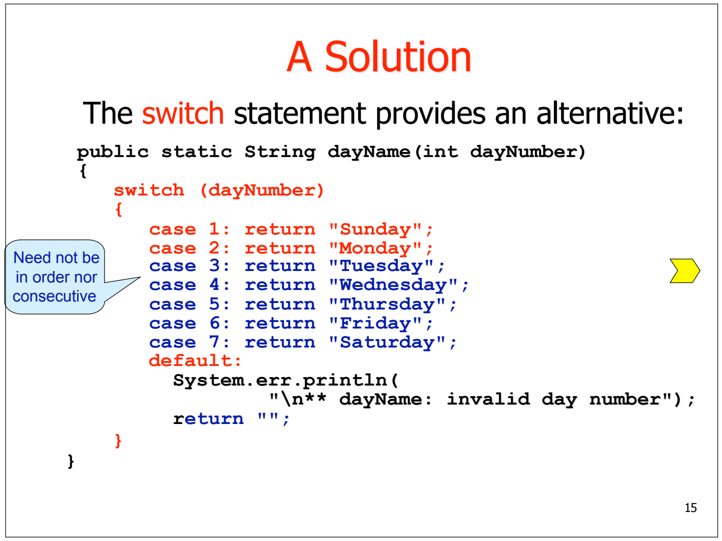

A Solution

The switch statement provides an alternative:

```
public static String dayName(int dayNumber)
{
   switch (dayNumber)
   {
      case 1: return "Sunday";
      case 2: return "Monday";
      case 3: return "Tuesday";
      case 4: return "Wednesday";
      case 5: return "Thursday";
      case 6: return "Friday";
      case 7: return "Saturday";
      default:
        System.err.println(
                "\n** dayName: invalid day number");
        return "";
   }
}
```

Need not be in order nor consecutive

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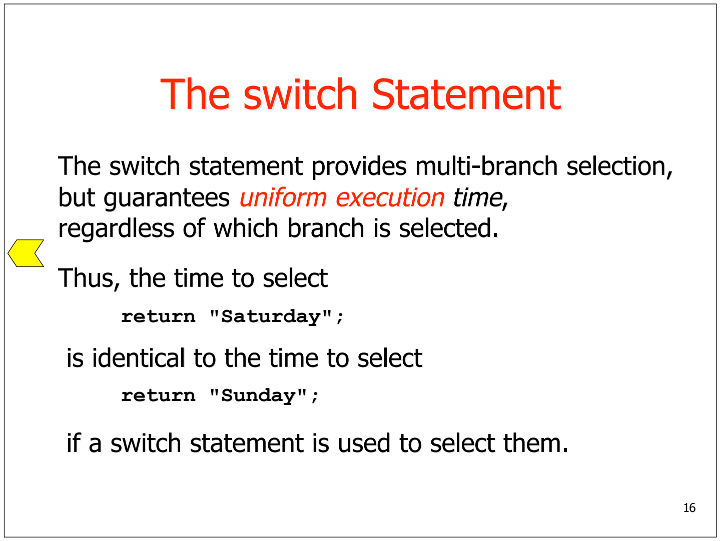

The switch Statement

The switch statement provides multi-branch selection, but guarantees *uniform execution time*, regardless of which branch is selected.

Thus, the time to select

```
return "Saturday";
```

is identical to the time to select

```
return "Sunday";
```

if a switch statement is used to select them.

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The switch Statement (ii)

Pattern:

```
switch (Expression)
{
 caseList1  StatementList1
 caseList2  StatementList2
 ...
 caseListN  StatementListN
 default:   StatementListN+1
}
```

where *expression* is an integer-compatible expression, each *caseList* is one or more *cases* of this form:

```
case ConstantValue :
```

and each *StatementList* usually ends with a **`break`** or **`return`** statement.

Example

Switch statements can use any *integer-compatible type*:

```
public static double
  straightPercentageCutOff(char letterGrade)
{
  switch(letterGrade)
  {
    case 'A': return 90.0;
    case 'B': return 80.0;
    case 'C': return 70.0;
    case 'D': return 60.0;
    case 'F': return 0.0;
    default:
      System.err.println(" \n** Invalid letter grade: "
                 + letterGrade
                 + " received by straightPercentageCutOff\n"
                 + "-- returning 999");
      return 999;
  }
}
```

They *cannot* be used with **`string`** or **`double`** values.

In class example -- inverse of **`straightPercentageCutOff()`**:
numeric score □ letter grade

```
public static char letterGrade(double
score)
{                    (     /10)
  switch( (int) score      )
  { case 10:
    case 9:  return 'A';
    case 8:  return 'B';
    case 7:  return 'C';
    case 6:  return 'D';
    default: return 'F';

  }
}
```

Another Restriction

To use the switch, the common algorithm pattern is:

if (*expression* == *CONSTANT*$_1$)
  {*statementlist*$_1$}
else if (*expression* == *CONSTANT*$_2$)
  {*statementlist*$_2$}
...
else if (*expression* == *CONSTANT*$_n$)
  {*statementlist*$_n$}
else
  {*statementlist*$_{n+1}$}

The pattern of a switch statement used to implement it is:

switch (*expression*)
{
  case *CONSTANT*$_1$:
      statementlist$_1$
  case *CONSTANT*$_2$:
      statementlist$_2$
  ...
  case *CONSTANT*$_n$:
      statementlist$_n$
  default:
      statementlist$_{n+1}$
}

Warning

Switch statements exhibit *drop-through behavior*.

1. *expression* is evaluated.
2. If *expression* == *CONSTANT*$_i$, control jumps to the *statementlist*$_i$ associated with *CONSTANT*$_i$.
3. Control continues within the switch statement until:
   a. The end of the switch is reached;
   b. A **break** is executed, terminating the switch;
   c. A **return** is executed, terminating the method; or
   d. Execution is terminated, e.g., with **exit()**.

Example

What will the following display,
 if the value of **dayNumber** is 4?

```
switch(dayNumber)
{
  case 1:  theScreen.print("Sunday");
  case 2:  theScreen.print("Monday");
  case 3:  theScreen.print("Tuesday");
  case 4:  theScreen.print("Wednesday");
  case 5:  theScreen.print("Thursday");
  case 6:  theScreen.print("Friday");
  case 7:  theScreen.print("Saturday");
  default: theScreen.println("Error!");
}
```

Output: **WednesdayThursdayFridaySaturdayError!**

Solution

To avoid the "drop-though" behavior, we need to add a **break** (or **return**) statement at the end of each case:

```
switch(dayNumber)
{
  case 1:  theScreen.print("Sunday");
           break;
  case 2:  theScreen.print("Monday");
           break;
  case 3:  theScreen.print("Tuesday");
           break;
 `case 4:  theScreen.print("Wednesday");
           break;
  case 5:  theScreen.print("Thursday");
           break;
  case 6:  theScreen.print("Friday");
           break;
  case 7:  theScreen.print("Saturday");
           break;
  default: theScreen.println("Error!");
}
```

Output when **dayNumber** is 4?

Wednesday

Selection: When to use **switch**

Use the switch statement for selection when

- You are comparing integer-compatible types (i.e., int, long, short, char, ...); *and*
- Your algorithm is of the form:

  if (*expression* == *CONSTANT*$_1$) *statementlist*$_1$
  else if (*expression* == *CONSTANT*$_2$) *statementlist*$_2$
  ...
  else if (*expression* == *CONSTANT*$_n$) *statementlist*$_n$
  else *statementlist*$_{n+1}$

Selection: When to use `if`

Use the if statement when

- You are comparing non-integer-compatible types (i.e., double, string, ...); *or*
- Your algorithm is of the more general form:

  if (*condition*$_1$) *statementlist*$_1$
  else if (*condition*$_2$) *statementlist*$_2$
  ...
  else if (*condition*$_n$) *statementlist*$_n$
  else *statementlist*$_{n+1}$

  where the *condition*$_i$ don't all have the form *expression* == *CONSTANT*$_i$ with the *expression* the same in each condition.

Example (Lab 7):

1. Menu:

```
Please enter:
   + to add two numbers;
   - to subtract two numbers;
   * to multiple two numbers; or
   / to divide two numbers.
-->
```

2. Read a choice
3. Use a(n) __**switch**__ (switch or if) statement to process the choice

Multi-Branch Selection: Conditional Expressions

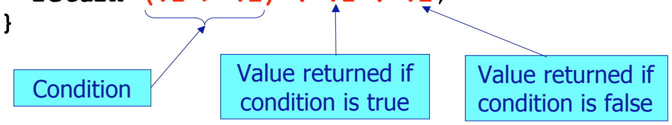
- There is a ternary operator: `? :`
  - it takes three operands
- Syntax:

  `condition ? expression`$_1$ `: expression`$_2$

  where:
  - `condition` is a boolean expression
  - `expression`$_1$ and `expression`$_2$ are of compatible types

Example: Find the smaller of two numbers:

```
public static int largerOf(int v1, int v2)
{
  return (v1 > v2) ? v1 : v2;
}
```


Condition
Value returned if condition is true
Value returned if condition is false

Example: Print a date – e.g., 10/21/02, 11/01/02

```
theScreen.print(
            month + "/" +
           (day < 10 ? "0" : "") + day
           (year < 10 ? "0" : "") + year );
```

Summary

- Java provides two selective execution statements:
  - The if statement.
  - The switch statement.
- The if statement is more general and can be used to solve any problem requiring selective behavior.
- The switch is more specialized, since it can only be used in special circumstances (equality comparisons), and on certain data types (integer-compatible).
- Java also has a ternary operator

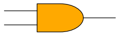
  `? :`

  used to form *conditional expressions* that can be used within other expressions – somewhat like putting an if statement inside an expression.

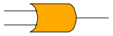
Part of the Picture: Boolean Logic & Digital Design

- Arithmetic operations performed by the CPU are carried out by logic circuits made up of three basic electronic components which mimic logical operators:

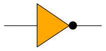
AND gate



OR gate



NOT gate (inverter)



- Logic circuits can be represented by boolean expressions.
- Basic axioms of Boolean algebra can be used to simplify these circuits

Circuit Design: A Binary Half-Adder

- Truth table

	0	1
0	0	1
1	1	10

digit1	digit2	carry	sum
0	0	0	0
0	1	0	1
1	0	0	1
1	1	1	0

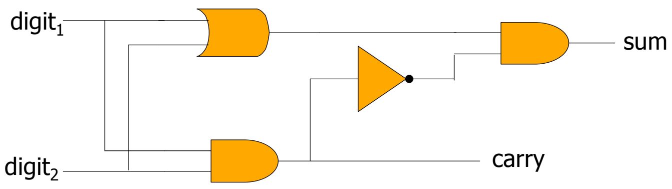
0 = false
1 = true

- Boolean expression equivalent:

```
boolean carry = digit1 && digit2,
        sum = (digit1 || digit2) &&
                  !(digit1 && digit2);
```

```
boolean carry = digit1 && digit2,
        sum = (digit1 || digit2) &&
                  !(digit1 && digit2);
```

- Digital circuit equivalent:



- Note binary half-adder class, source code, Figure 7.9, test driver Figure 7.10