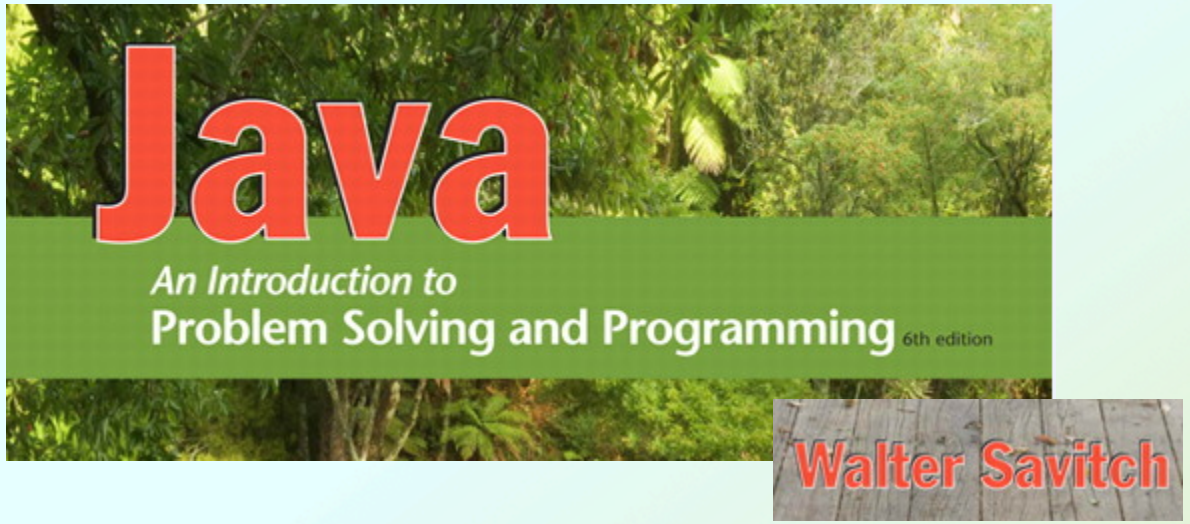


Arrays

Chapter 7

*JAVA: An Introduction to Problem Solving & Programming, 6*th Ed. By Walter Savitch
ISBN 0132162709

Objectives

- Nature and purpose of an array
- Using arrays in Java programs
- Methods with array parameter
- Methods that return an array
- Array as an instance variable
- Use an array not filled completely

Objectives

- Order (sort) the elements of an array
- Search an array for a particular item
- Define, use multidimensional array
- Text fields, text areas in applets
- Drawing arbitrary polygons in applets

Array Basics: Outline

- Creating and Accessing Arrays
- Array Details
- The Instance Variable length
- More About Array Indices
- Analyzing Arrays

Creating and Accessing Arrays

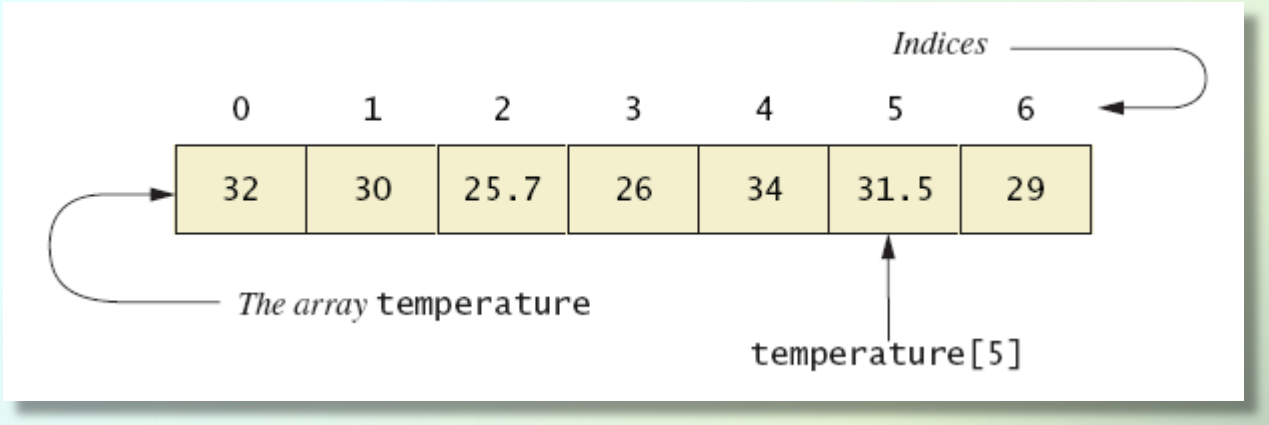
- An array is a special kind of object
- Think of as collection of variables of same type
- Creating an array with 7 variables of type double

```
double[] temperature = new double[7];
```

- To access an element use
  - The name of the array
  - An index number enclosed in braces
- Array indices begin at zero

Creating and Accessing Arrays

- Figure 7.1 A common way to visualize an array



- Note sample program, listing 7.1

```
class ArrayOfTemperatures
```

Creating and Accessing Arrays

```
Enter 7 temperatures:
32
30
25.7
26
34
31.5
29
The average temperature is 29.7428
The temperatures are
32.0 above average
30.0 above average
25.7 below average
26.0 below average
34.0 above average
31.5 above average
29.0 below average
Have a nice week.
```

Sample screen output

Array Details

- Syntax for declaring an array with **`new`**

```
Base_Type[] Array_Name = new Base_Type[Length];
```

- The number of elements in an array is its length
- The type of the array elements is the array's base type

Square Brackets with Arrays

- With a data type when declaring an array

```
int [ ] pressure;
```

- To enclose an integer expression to declare the length of the array

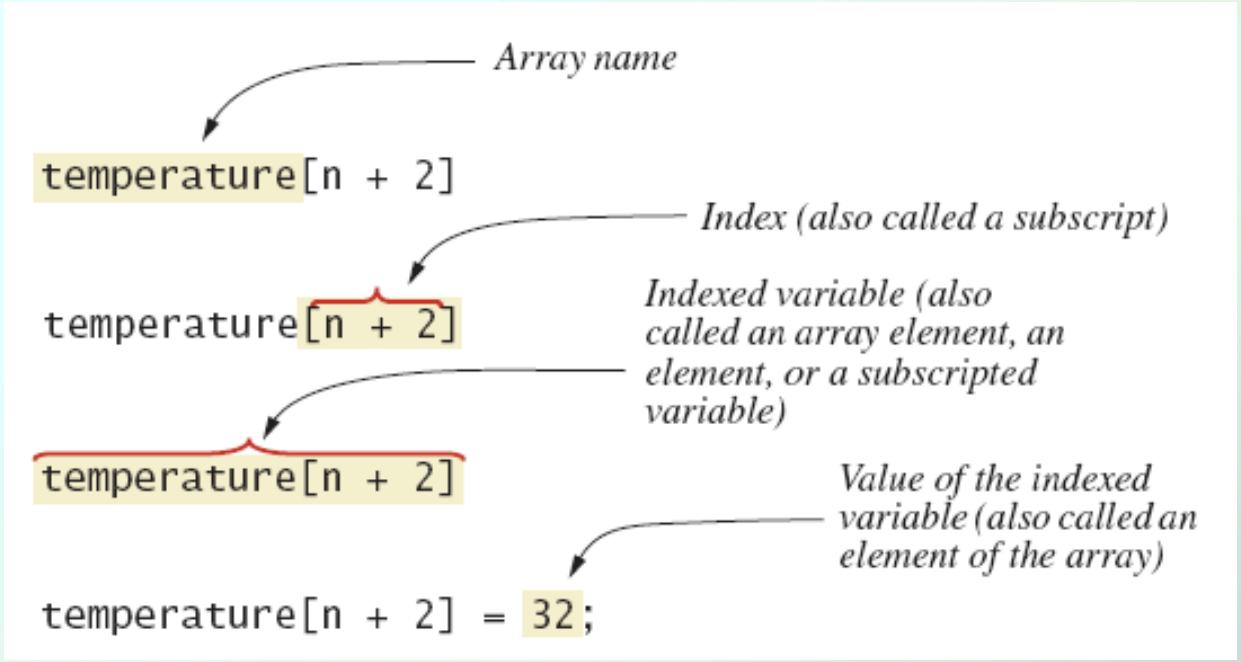
```
pressure = new int [100];
```

- To name an indexed value of the array

```
pressure[3] = keyboard.nextInt();
```

Array Details

- Figure 7.2 Array terminology



The Instance Variable `length`

- As an object an array has only one public instance variable
  - Variable **`length`**
  - Contains number of elements in the array
  - It is final, value cannot be changed
- Note revised code, listing 7.2
  `class ArrayOfTemperatures2`

The Instance Variable `length`

```
How many temperatures do you have?
3
Enter 3 temperatures:
32
26.5
27
The average temperature is 28.5
The temperatures are
32.0 above average
26.5 below average
27.0 below average
Have a nice week.
```

Sample screen output

More About Array Indices

- Index of first array element is 0
- Last valid Index is `arrayName.length - 1`
- Array indices must be within bounds to be valid
  - When program tries to access outside bounds, run time error occurs
- OK to "waste" element 0
  - Program easier to manage and understand
  - Yet, get used to using index 0

Initializing Arrays

- Possible to initialize at declaration time

```
double[] reading = {3.3, 15.8, 9.7};
```

- Also may use normal assignment statements
  - One at a time
  - In a loop

```
int[] count = new int[100];
for (int i = 0; i < 100; i++)
    count[i] = 0;
```

Arrays in Classes and Methods: Outline

- Case Study: Sales Report
- Indexed Variables as Method Arguments
- Entire Arrays as Arguments to a Method
- Arguments for the Method main
- Array Assignment and Equality
- Methods that Return Arrays

Case Study: Sales Report

- Program to generate a sales report
- Class will contain
  - Name
  - Sales figure
- View class declaration, listing 7.3

```
class SalesAssociate
```

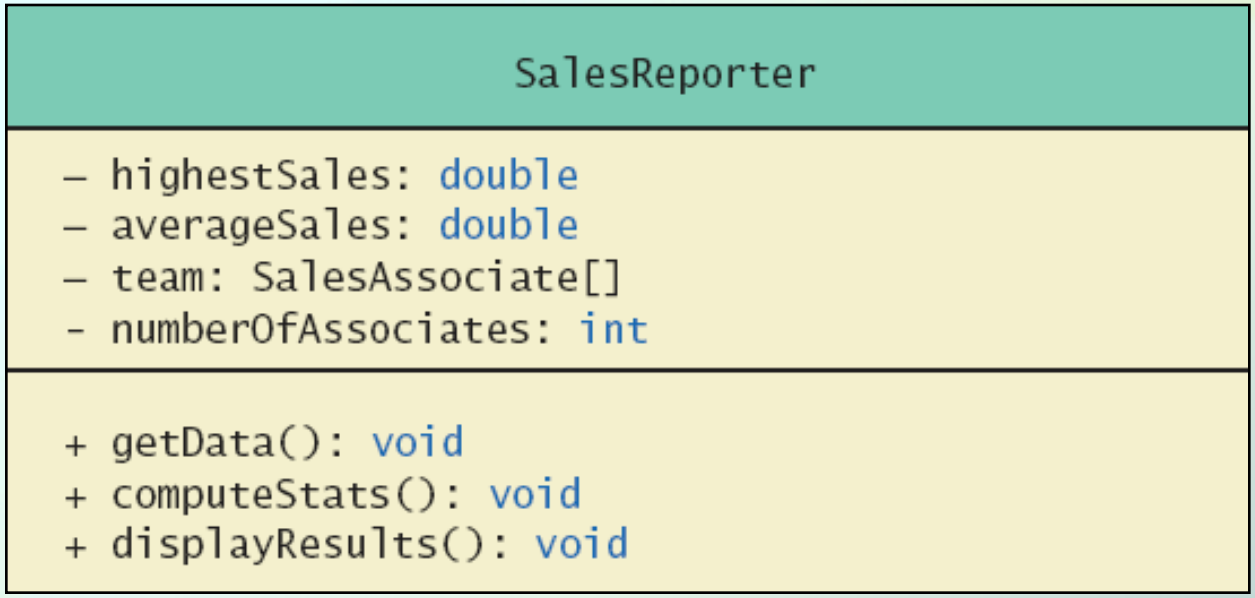
Case Study: Sales Report

Main subtasks for our program

1. Get ready
2. Obtain the data
3. Compute some statistics (update instance variables)
4. Display the results

Case Study: Sales Report

- Figure 7.3 Class diagram for class **`SalesReporter`**



Case Study: Sales Report

- View sales report program, listing 7.4

`class SalesReporter`

```
Average sales per associate is $32000.0
The highest sales figure is $50000.0

The following had the highest sales:
Name: Natalie Dressed
Sales: $50000.0
$18000.0 above the average.

The rest performed as follows:
Name: Dusty Rhodes
Sales: $36000.0
$4000.0 above the average.

Name: Sandy Hair
Sales: $10000.0
$22000.0 below the average.
```

Sample screen output

Indexed Variables as Method Arguments

- Indexed variable of an array
  - Example … **`a[i]`**
  - Can be used anywhere variable of array base type can be used
- View program using indexed variable as an argument, listing 7.5

  `class ArgumentDemo`

Entire Arrays as Arguments

- Declaration of array parameter similar to how an array is declared
- Example:

```
public class SampleClass
{
    public static void incrementArrayBy2(double[] anArray)
    {
        for (int i = 0; i < anArray.length; i++)
            anArray[i] = anArray[i] + 2;
    }
    <The rest of the class definition goes here.>
}
```

Entire Arrays as Arguments

- Note – array parameter in a method heading does not specify the length
  - An array of any length can be passed to the method
  - Inside the method, elements of the array can be changed
- When you pass the entire array, do not use square brackets in the actual parameter

Arguments for Method main

- Recall heading of method **`main`**
  `public static void main (String[] args)`
- This declares an array
  - Formal parameter named **`args`**
  - Its base type is **`String`**
- Thus possible to pass to the run of a program multiple strings
  - These can then be used by the program

Array Assignment and Equality

- Arrays are objects
  - Assignment and equality operators behave (misbehave) as specified in previous chapter
- Variable for the array object contains memory address of the object
  - Assignment operator **=** copies this address
  - Equality operator **==** tests whether two arrays are stored in same place in memory

Array Assignment and Equality

- Two kinds of equality
- View example program, listing 7.6

`class TestEquals`

Sample screen output

```
Not equal by ==.
Equal by the equals method.
```

Array Assignment and Equality

- Note results of **==**
- Note definition and use of method **`equals`**
  - Receives two array parameters
  - Checks length and each individual pair of array elements
- Remember array types are reference types

Methods that Return Arrays

- A Java method may return an array
- View example program, listing 7.7
  `class ReturnArrayDemo`
- Note definition of return type as an array
- To return the array value
  - Declare a local array
  - Use that identifier in the `return` statement

Programming with Arrays and Classes: Outline

- Programming Example: A Specialized List Class
- Partially Filled Arrays

Programming Example

- A specialized List class
  - Objects can be used for keeping lists of items
- Methods include
  - Capability to add items to the list
  - Also delete entire list, start with blank list
  - But no method to modify or delete list item
- Maximum number of items can be specified

Programming Example

- View demo program, listing 7.8
  `class ListDemo`
- Note declaration of the list object
- Note method calls

Programming Example

```
Enter items for the list, when prompted.
Enter an item:
Buy milk
More items for the list? yes
Enter an item:
Walk dog
More items for the list? yes
Enter an item:
Buy milk
More items for the list? yes
Enter an item:
Write program
The list is now full.
The list contains:
Buy milk
Walk dog
Write program
```

Sample screen output

Programming Example

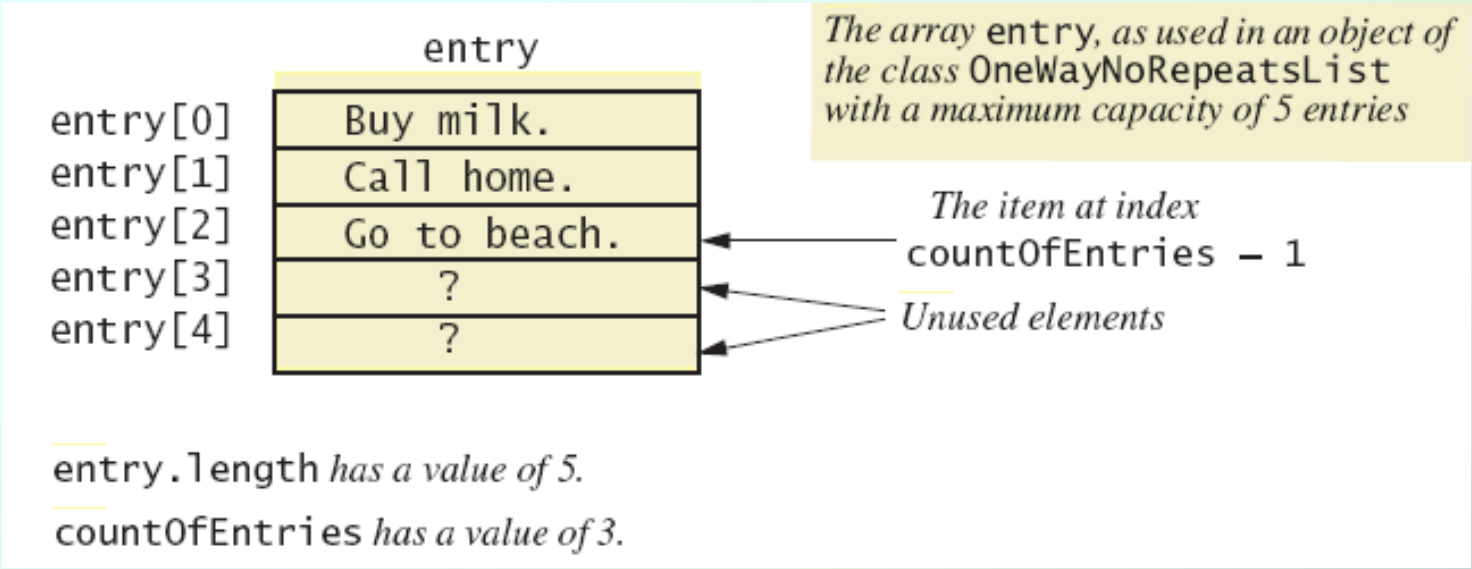
- Now view array wrapped in a class to represent a list, listing 7.9
  `class OneWayNoRepeatsList`
- Notable code elements
  - Declaration of private array
  - Method to find n^{th} list item
  - Method to check if item is on the list or not

Partially Filled Arrays

- Array size specified at definition
- Not all elements of the array might receive values
  - This is termed a *partially filled array*
- Programmer must keep track of how much of array is used

Partially Filled Arrays

- Figure 7.4 A partially filled array



Sorting, Searching Arrays: Outline

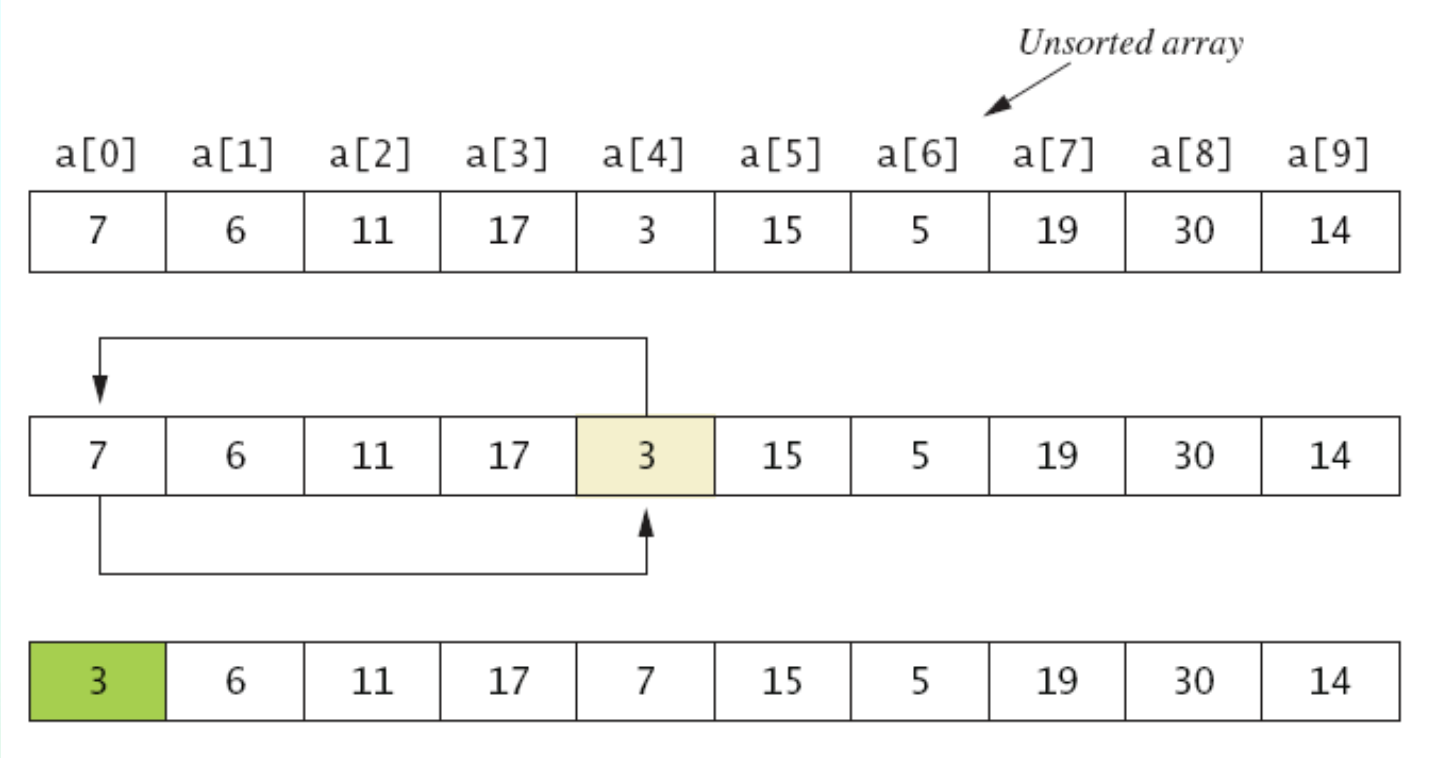
- Selection Sort
- Other Sorting Algorithms
- Searching an Array

Selection Sort

- Consider arranging all elements of an array so they are ascending order
- Algorithm is to step through the array
  - Place smallest element in index 0
  - Swap elements as needed to accomplish this
- Called an interchange sorting algorithm

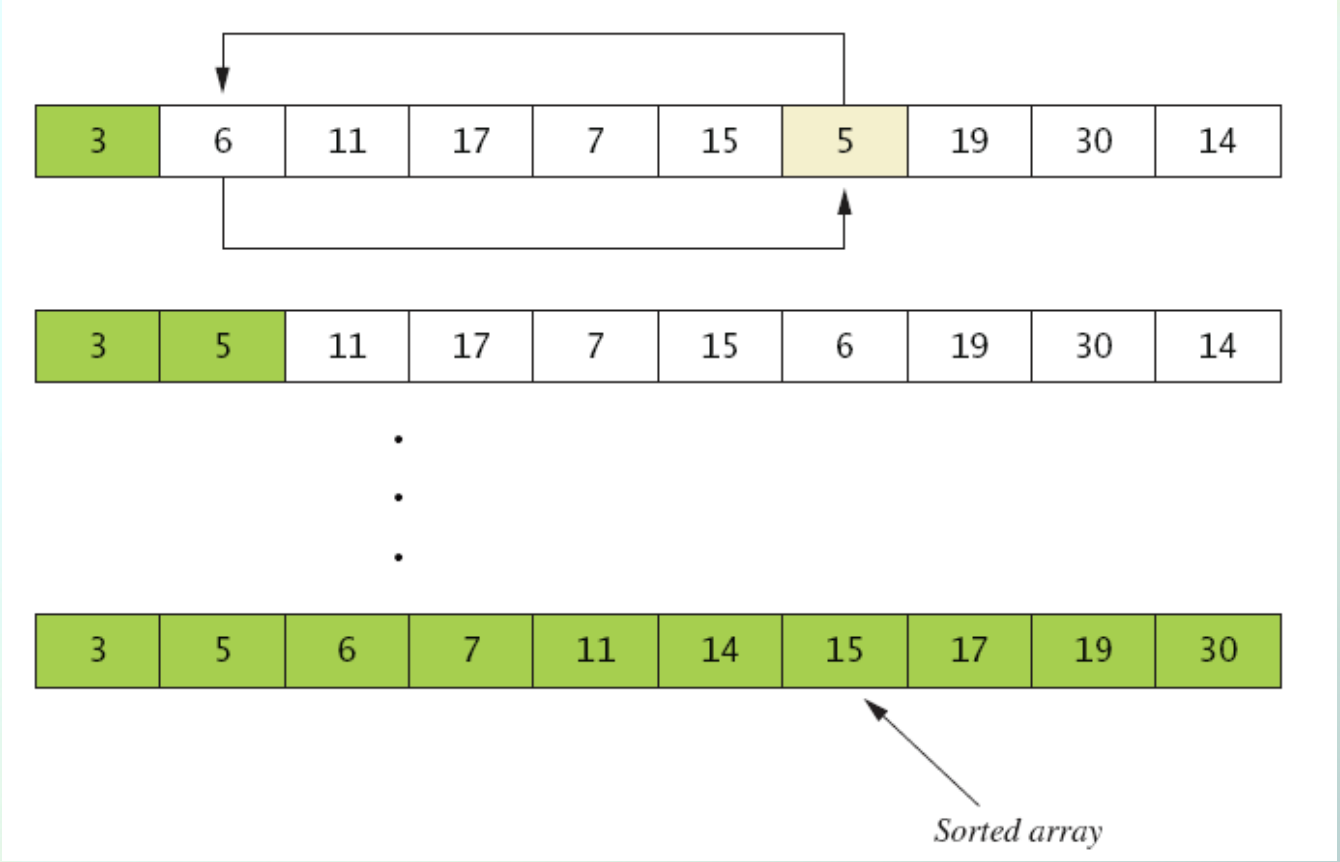
Selection Sort

- Figure 7.5a



Selection Sort

- Figure 7.5b



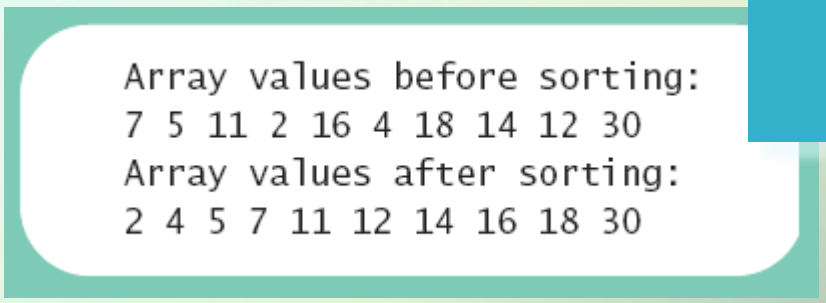
Selection Sort

- Algorithm for selection sort of an array

```
for (index = 0; index < a.length – 1; index++)
{// Place the correct value in a[index]:
    indexOfNextSmallest = the index of the smallest value among
                          a[index], a[index+1], ..., a[a.length – 1]
    Interchange the values of a[index] and a[indexOfNextSmallest].
    // Assertion: a[0] <= a[1] <=...<= a[index] and these
    // are the smallest of the original array elements.
    // The remaining positions contain the rest of the
    // original array elements.
}
```

Selection Sort

- View implementation of selection sort, listing 7.10
  `class ArraySorter`
- View demo program, listing 7.11
  `class SelectionSortDemo`



Sample screen output

Other Sorting Algorithms

- Selection sort is simplest
  - But it is very inefficient for large arrays
- Java Class Library provides for efficient sorting
  - Has a class called Arrays
  - Class has multiple versions of a sort method

Searching an Array

- Method used in **`OneWayNoRepeatsList`** is sequential search
  - Looks in order from first to last
  - Good for unsorted arrays
- Search ends when
  - Item is found … or …
  - End of list is reached
- If list is sorted, use more efficient searches

Multidimensional Arrays: Outline

- Multidimensional-Array Basics
- Multidimensional-Array Parameters and Returned Values
- Java's Representation of Multidimensional
- Ragged Arrays
- Programming Example: Employee Time Records

Multidimensional-Array Basics

- Consider Figure 7.6, a table of values

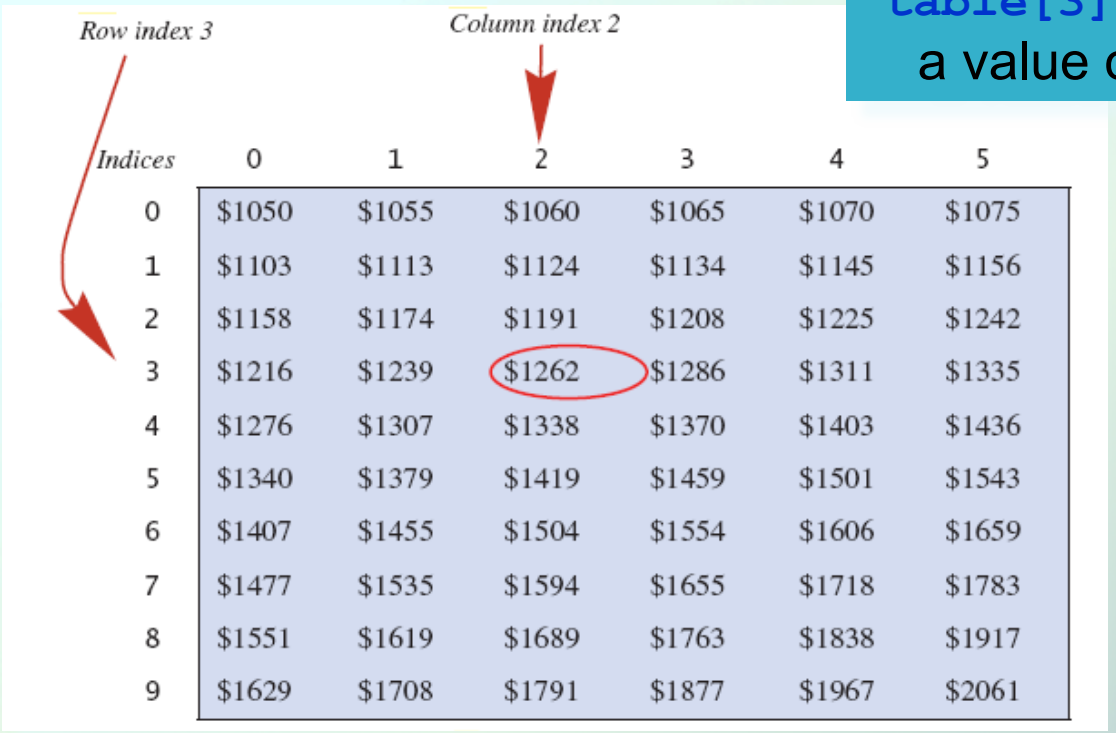
Savings Account Balances for Various Interest Rates Compounded Annually (Rounded to Whole Dollar Amounts)

Year	5.00%	5.50%	6.00%	6.50%	7.00%	7.50%
1	$1050	$1055	$1060	$1065	$1070	$1075
2	$1103	$1113	$1124	$1134	$1145	$1156
3	$1158	$1174	$1191	$1208	$1225	$1242
4	$1216	$1239	$1262	$1286	$1311	$1335
5	$1276	$1307	$1338	$1370	$1403	$1436
6	$1340	$1379	$1419	$1459	$1501	$1543
7	$1407	$1455	$1504	$1554	$1606	$1659
8	$1477	$1535	$1594	$1655	$1718	$1783
9	$1551	$1619	$1689	$1763	$1838	$1917
10	$1629	$1708	$1791	$1877	$1967	$2061

Multidimensional-Array Basics

- Figure 7.7 Row and column indices for an array named **`table`**

`table[3][2]` has a value of 1262



Indices	0	1	2	3	4	5
0	$1050	$1055	$1060	$1065	$1070	$1075
1	$1103	$1113	$1124	$1134	$1145	$1156
2	$1158	$1174	$1191	$1208	$1225	$1242
3	$1216	$1239	$1262	$1286	$1311	$1335
4	$1276	$1307	$1338	$1370	$1403	$1436
5	$1340	$1379	$1419	$1459	$1501	$1543
6	$1407	$1455	$1504	$1554	$1606	$1659
7	$1477	$1535	$1594	$1655	$1718	$1783
8	$1551	$1619	$1689	$1763	$1838	$1917
9	$1629	$1708	$1791	$1877	$1967	$2061

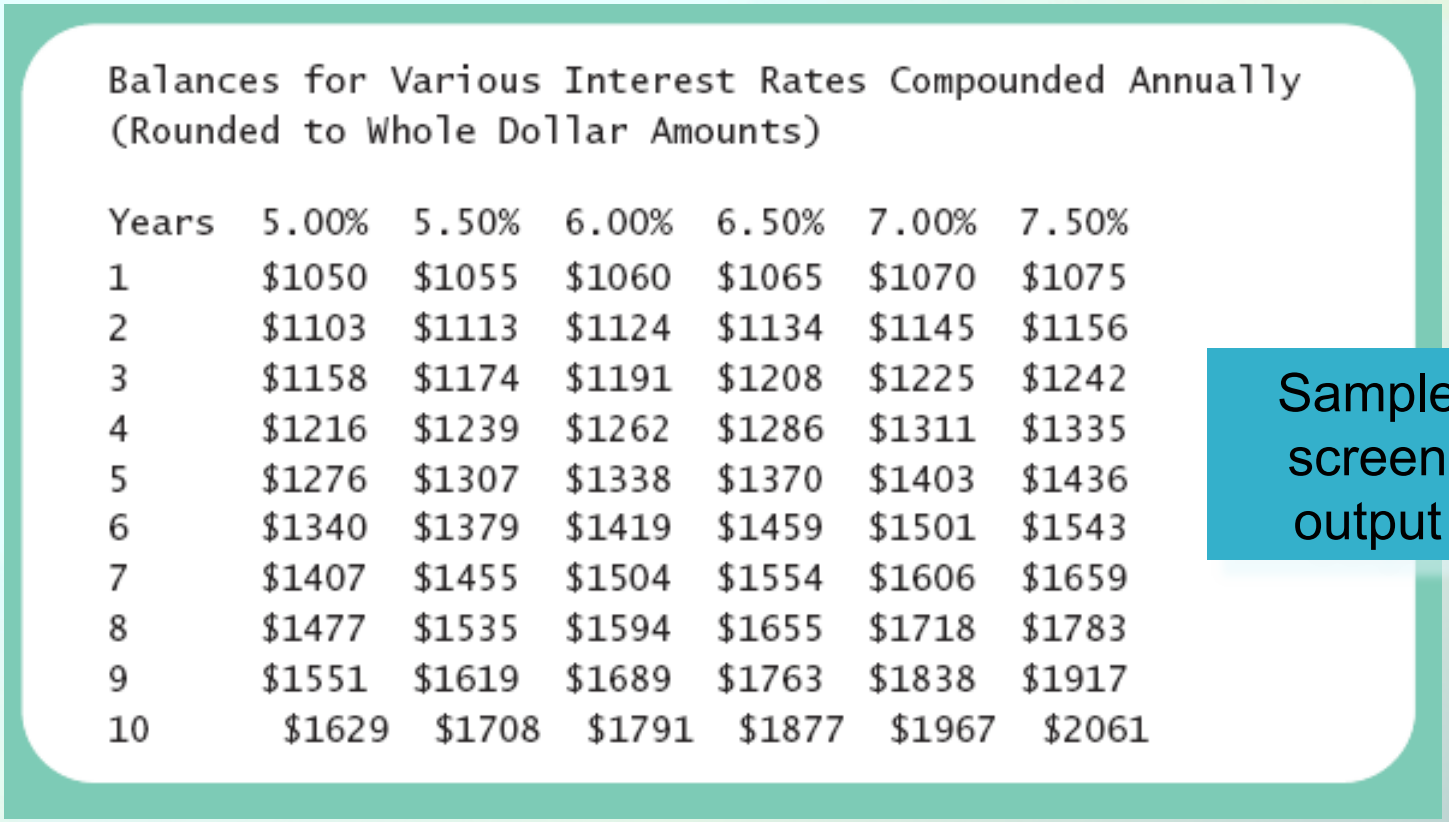
Multidimensional-Array Basics

- We can access elements of the table with a nested for loop
- Example:

```
for (int row = 0; row < 10; row++)
   for (int column = 0; column < 6; column++)
      table[row][column] =
          balance(1000.00, row + 1, (5 + 0.5 * column));
```

- View sample program, listing 7.12
  `class InterestTable`

Multidimensional-Array Basics



Balances for Various Interest Rates Compounded Annually
(Rounded to Whole Dollar Amounts)

Years	5.00%	5.50%	6.00%	6.50%	7.00%	7.50%
1	$1050	$1055	$1060	$1065	$1070	$1075
2	$1103	$1113	$1124	$1134	$1145	$1156
3	$1158	$1174	$1191	$1208	$1225	$1242
4	$1216	$1239	$1262	$1286	$1311	$1335
5	$1276	$1307	$1338	$1370	$1403	$1436
6	$1340	$1379	$1419	$1459	$1501	$1543
7	$1407	$1455	$1504	$1554	$1606	$1659
8	$1477	$1535	$1594	$1655	$1718	$1783
9	$1551	$1619	$1689	$1763	$1838	$1917
10	$1629	$1708	$1791	$1877	$1967	$2061

Sample screen output

Multidimensional-Array Parameters and Returned Values

- Methods can have
  - Parameters that are multidimensional-arrays
  - Return values that are multidimensional-arrays
- View sample code, listing 7.13
  `class InterestTable2`

Java's Representation of Multidimensional Arrays

- Multidimensional array represented as several one-dimensional arrays
- Given

```
int [][] table = new int [10][6];
```

- Array table is actually 1 dimensional of type `int[]`
  - It is an array of arrays
- Important when sequencing through multidimensional array

Ragged Arrays

- Not necessary for all rows to be of the same length
- Example:

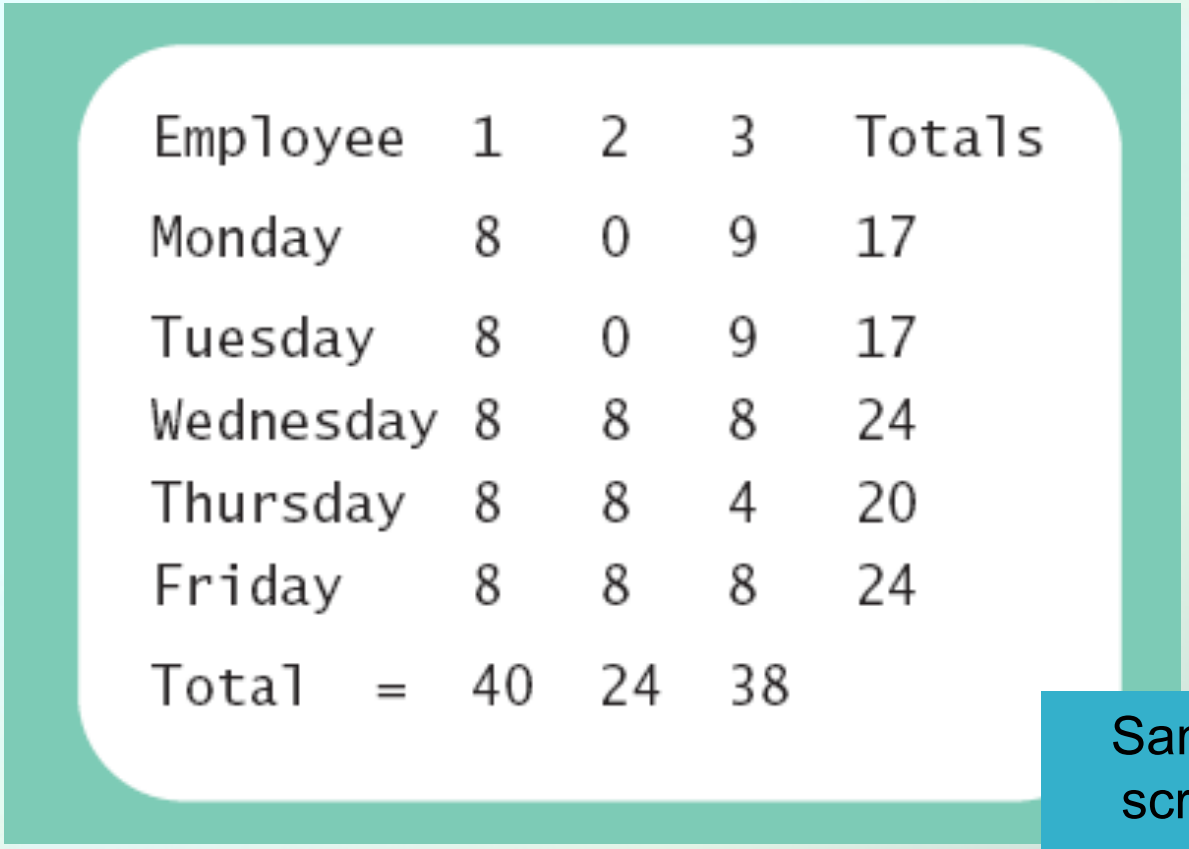
```
int[][] b;
b = new int[3][];
b[0] = new int[5]; //First row,  5 elements
b[1] = new int[7]; //Second row, 7 elements
b[2] = new int[4]; //Third row,  4 elements
```

Programming Example

- Employee Time Records
  - Two-dimensional array stores hours worked
    - For each employee
    - For each of 5 days of work week
  - Array is private instance variable of class
- View sample program, listing 7.14

```
class TimeBook
```

Programming Example

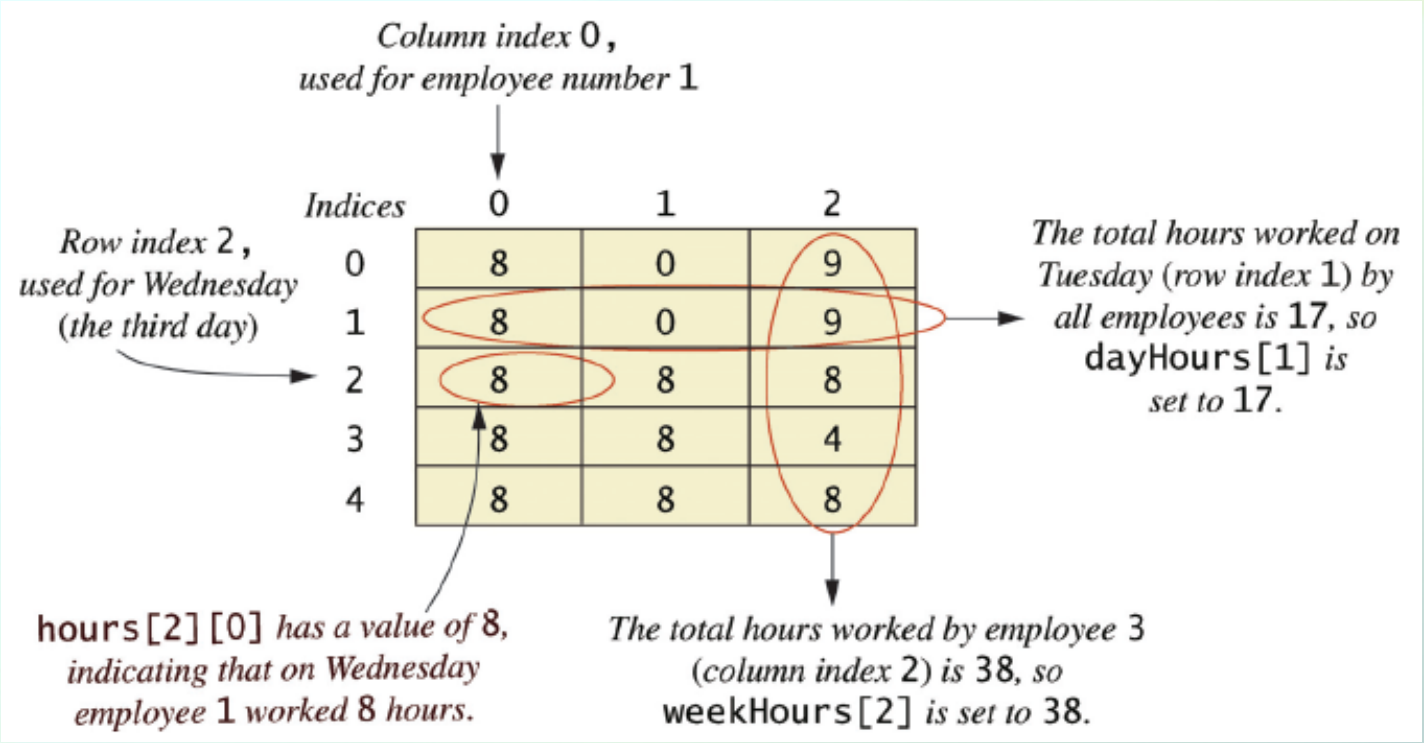


```
Employee   1    2    3    Totals
Monday     8    0    9    17
Tuesday    8    0    9    17
Wednesday  8    8    8    24
Thursday   8    8    4    20
Friday     8    8    8    24
Total  =   40   24   38
```

Sample screen output

Programming Example

- Figure 7.8 Arrays for the class **`TimeBook`**

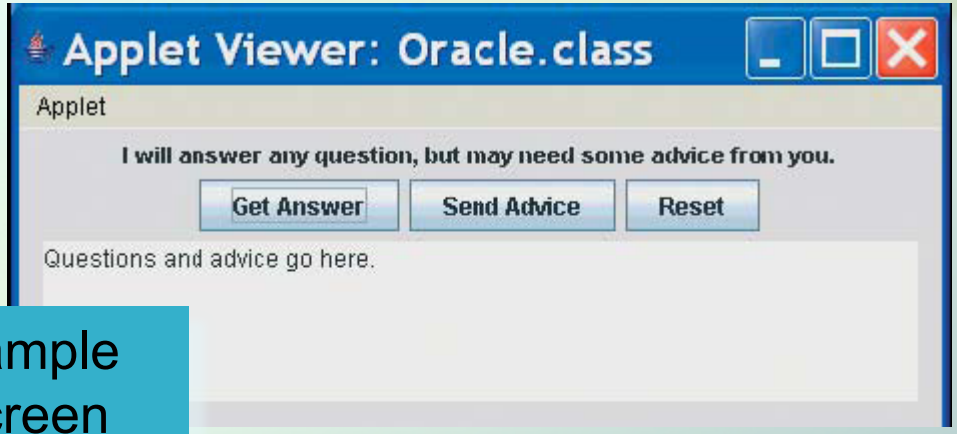


Graphics Supplement: Outline

- Text Areas and Text Fields
- Programming Example: A Question-and-Answer Applet
- The Classes **`JTextArea`** and **`JTextField`**
- Drawing Polygons

Text Areas, Text Fields

- Text area is object of class **`JTextArea`**
  - Displayed as a place for user to enter multiple lines of text
- View sample code, listing 7.15 class Oracle



Sample screen output

JTextArea and `JTextField`

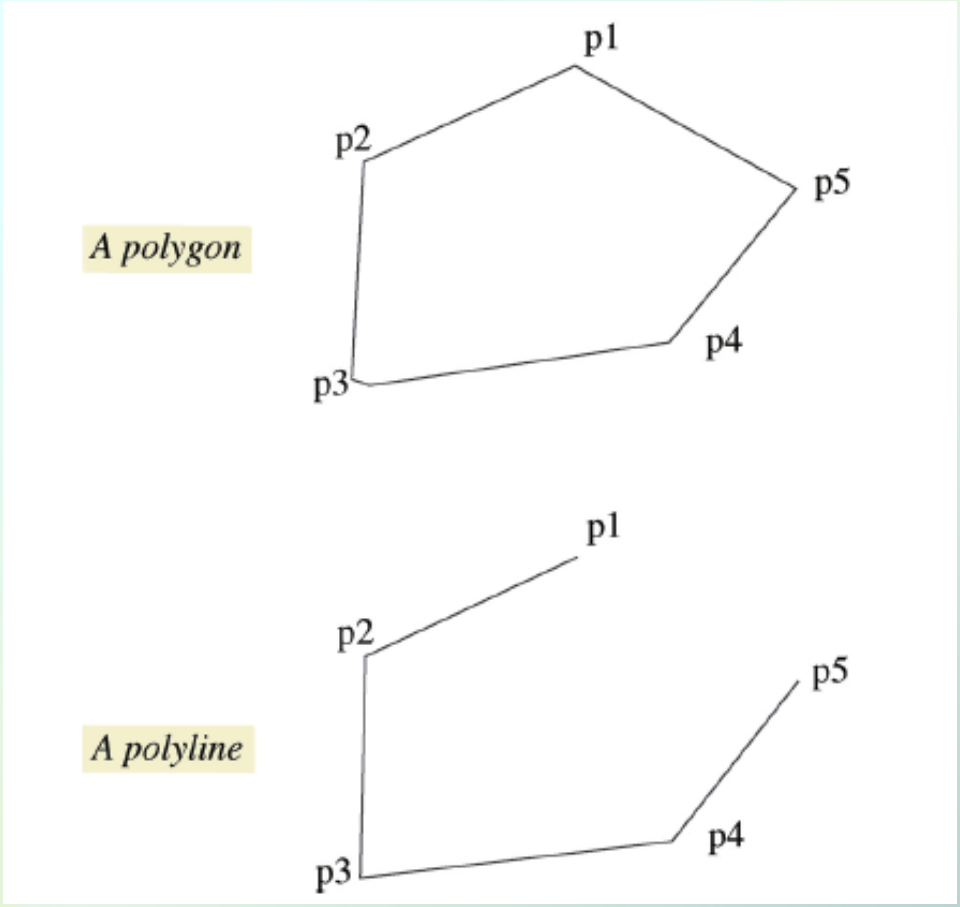
- Class `JTextArea`
  - Used for multiple lines of user input
- Class `JtextField`
  - Used for single line of user input
- Both classes include methods
  - `setText`
  - `getText`

Drawing Polygons

- Class Graphics has method **`drawRect`**
  - But only 4 sides and only 90 degree corners
- Method **`drawPolygon`** can draw polygon of any number of sides
  - Three arguments
    - Array of **`int`** for x values of coordinates
    - Array of **`int`** for y values of coordinates
    - Number of points (vertices)
- A *polyline* like a polygon, not closed

Drawing Polygons

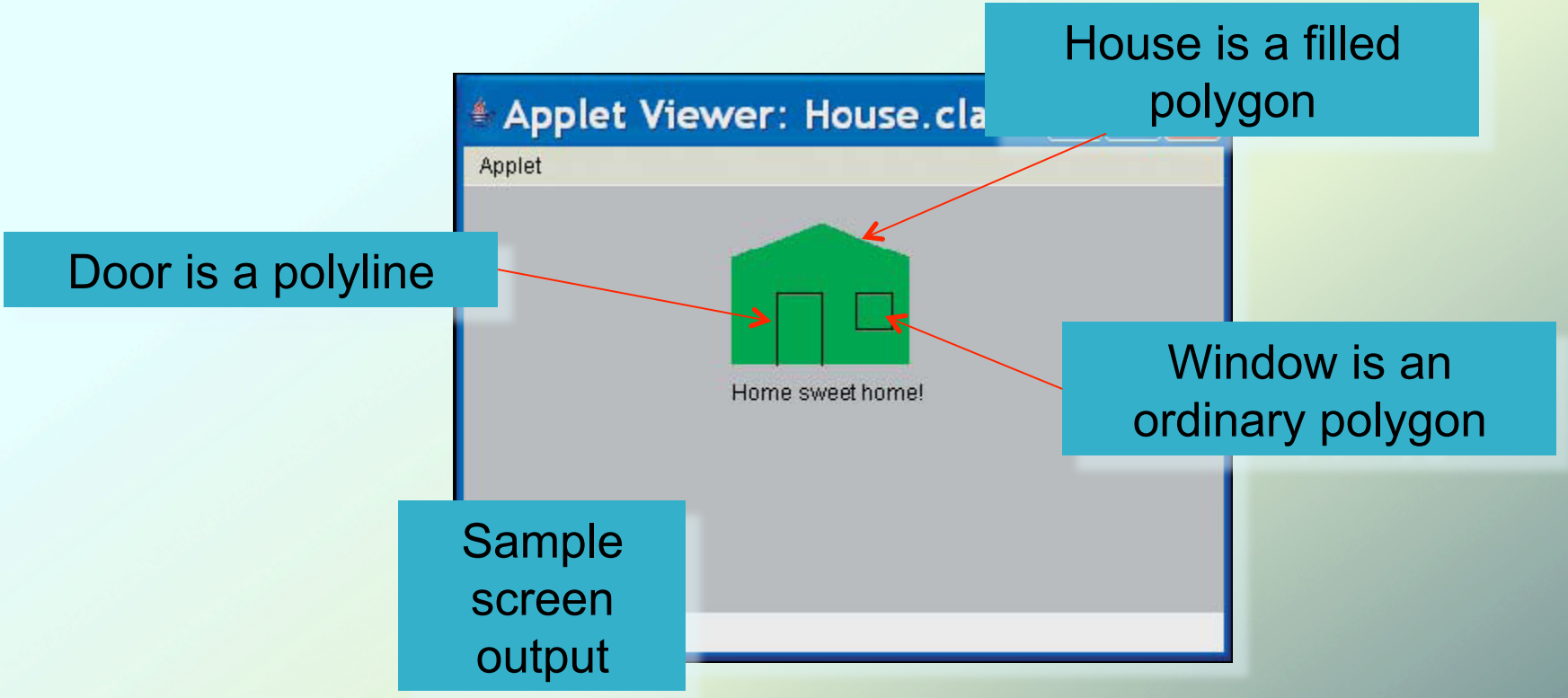
- Figure 7.9
  A polygon and
  a polyline



Drawing Polygons

- View sample applet, listing 7.16

  `class House`



Summary

- An array is a collection of variables all of the same type
- Arrays are objects, created with operator new
- Elements numbered starting with 0, ending with 1 less than length
- Indexed variable can be used as a parameter – treated like variable of base type

Summary

- Entire array can be passed as parameter to a method
- Method return value can be an array
- Partially filled array usually stores values in initial segment, use an `int` to track how many are used
- Privacy leak caused by returning array corresponding to private instance variable

Summary

- Selection sort orders an array into ascending or descending order
- Multidimensional arrays are implemented as an array of arrays
- Treat two-dimensional array as a table with rows and columns
- Text fields, text areas in an applet provide areas for text input/output
- Possible to draw polygons, polylines in an applet