Structural Programming and Data Structures

Winter 2000

CMPUT 102: Vectors and other Repetitions

Dr. Osmar R. Zaïane

University of Alberta

Course Content

- Introduction
- Objects
- Methods
- Tracing Programs
- Object State
- Sharing resources
- Selection
- Repetition
- **Vectors**
- Testing/Debugging
- Arrays
- Searching
- Files I/O
- Sorting
- Inheritance
- Recursion

Objectives of Lecture 17

Vectors and For Statements

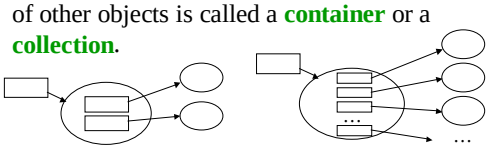
- learn about container objects that can contain an arbitrary number of other objects.
- See the Vector object as an example of a container.
- Introduce a repetition control structure called the for statement that allows the iteration over indexed collections.
- Re-write the Adventure program using the concept of vectors .

Outline of Lecture 17

- Containers
- Vectors
- The for statement
- Adventure Version 8

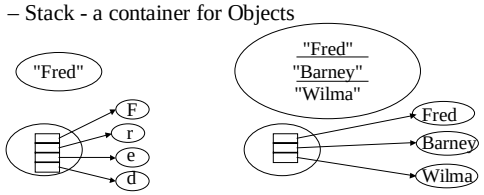
Containers

- An object's state consists of instance variables that are bound to other objects or values.
- Sometimes it is useful for an object's state to include an arbitrary number of other objects.
- An object that remembers an arbitrary number of other objects is called a **container** or a **collection**.



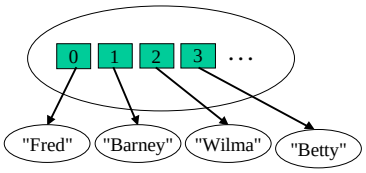
Strings and Stacks

- We have already seen two containers:
  - String - a container for characters
  - Stack - a container for Objects



Indexed Containers

- Containers whose elements are indexed by integers are called indexed containers.
- The integer indexes are the object references.



Examples of Indexed Lists

List of students and their grades

1	Jane Doe	90
2	Bob Smith	85
3	John Flint	83
4	Wilma Stone	79
5	Fred Ming	75
...		

Who is the 10th student?

List of cities I visited

1	Edmonton
2	Vancouver
3	Denver
4	San Diego

What is the 3 city?

With a stack, I can only see the top element.

Outline of Lecture 17

- Containers
- Vectors
- The for statement
- Adventure Version 8

Java - Vector 1

- Java has a class called Vector, that is an ordered indexed container of an arbitrary number of Objects.
- A Vector, can hold any kind of Objects, but not values.

```
Vector      myCities;
myCities = new Vector();
myCities.addElement("Edmonton");
myCities.addElement("Vancouver");
myCities.addElement("Denver");
myCities.addElement("San Diego");
```

Vector addElement

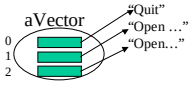
Java - Vector 2

- A Vector is indexed by non-negative ints so it can be accessed by position
- The first position is 0, not 1.
- A Vector knows its current size.
- A Vector can be iterated by index.
- When you access an Object in a Vector, you often must **cast** its type to use it.

Java - Vector 3

```
String  element;
int index;
Vector aVector;
aVector = new Vector();
aVector.addElement("Quit");
aVector.addElement("Open the chest");
aVector.addElement("Open the blue door");

index = 0;
While (index < aVector.size()) {
   element = (String) aVector.elementAt(index);
   System.out.println(element);
   index = index + 1;
}
```



Outline of Lecture 17

- Containers
- Vectors
- The for statement
- Adventure Version 8

Java Syntax: for Statement

- A **for** statement is a special repetition control structure for indexed collections.
- The syntax of a for statement in Java is:

<for statement> ::= for (<assignment>; <condition>; <increment>)
    <statement>

Java shorthand for: index = index + 1;

- For example:

```
for (index = 0; index < aVector.size(); index++) {
    element = (String) aVector.elementAt(index);
    System.out.println(element);
}
```


Semantics - for

- The assignment is executed to initialize the index variable.
- The condition is evaluated and if it is true the statement is executed.
- The increment is performed on the index variable.
- The condition is re-evaluated and if it is true, the statement is executed again.
- This continues until the condition is false at which time the for statement is done.

for Semantics - Example

```
Vector aVector;
int    index;
String element;
aVector = new Vector();
aVector.addElement("Quit");
aVector.addElement("Open the chest");
aVector.addElement("Open the blue door");
for (index = 0; index < aVector.size(); index++) {
        element = (String) aVector.elementAt(index);
        System.out.println(element);
  }
```

```
Quit
Open the Chest
Open the blue door
```


Outline of Lecture 17

- Containers
- Vectors
- The for statement
- Adventure Version 8

Adventure 8

- Use Vectors to modify the Arithmetic Adventure game so that many rooms are supported.
- Use Vectors to improve the implementation of TextMenu.

Adventure 8 - Changes Summary

- Add the class Door.
- Make many changes to class Adventure.
- Make many changes to class Room.
- Make changes to class TextMenu.
- Leave the classes: Adventurer, RandomInt, Chest and Question unchanged.

Running Adventure 8 (1)

Running Adventure 8 (2)

Running Adventure 8 (3)

Running Adventure 8 (4)

Running Adventure 8 (5)

Program - Adventure 7.1

OLD

```
import java.util.*;
public class Adventure {
/* Version 7
   This program is an arithmetic adventure game …
*/

/* Constructors */

   public Adventure () {
   /*
         Initialize an adventure by creating the appropriate
         objects.
   */
         this.firstRoom = new Room(1);
   }
```


Program - Adventure 8.1

NEW

```
import java.util.*;
public class Adventure {
/* Version 8 This program is an arithmetic … */
/* Constructors */
   public Adventure () {
   /*   Initialize an adventure by creating the appropriate
        objects.
   */
         Vector rooms;
         int i;
         rooms = new Vector();
         for (i = 0; i <= 4; i++)
               rooms.addElement(new Room(i + 1));
         this.makeDoor(rooms, 1, 2, "red");
```


OLD

Program - Adventure 7.2

```
/* Main program */

   public static void main(String args[]) {
         Adventure      game;

         game = new Adventure();
         game.play();
   }

/* Private Instance Variables */

   private Room firstRoom;
```


Program - Adventure 8.2

NEW

```
         this.makeDoor(rooms, 1, 3, "blue");
         this.makeDoor(rooms, 2, 4, "green");
         this.makeDoor(rooms, 2, 5, "blue");
         this.firstRoom = (Room) rooms.elementAt(0);
   }

/* Main program */
   public static void main(String args[]) {
         Adventure      game;
         game = new Adventure();
         game.play();
   }
/* Private Instance Variables */
   private Room firstRoom;
```


Program - Adventure 7.3

```
/* Private Instance Methods */

   private void play() {
   /*
         Plays the Adventure game.
   */

         Adventurer     adventurer;
         Room           room;

         adventurer = this.greeting();
         room = firstRoom.enter(adventurer);
         this.farewell(adventurer);
   }
```

OLD

Program - Adventure 8.3

```
/* Private Instance Methods */
   private void play() {
   /*
         Plays the Adventure game.
   */
         Adventurer     adventurer;
         Room           room;

         adventurer = this.greeting();
         room = firstRoom;
         while (room != null)
               room = room.enter(adventurer);
         this.farewell(adventurer);
   }
```

NEW

Program - Adventure 8.4

NO CHANGES

```
private Adventurer greeting() {
/*
     Great the user and answer an Adventurer that
     represents the user.
*/
     String  playerName;

     System.out.println("Welcome to the Arithmetic Adventure game.");
     System.out.print("The date is ");
     System.out.println(new Date());
     System.out.println();
     System.out.print("What is your name?");
     playerName = Keyboard.in.readString();
```


NO CHANGES

Program - Adventure 8.5

```
     System.out.print("Well ");
     System.out.print(playerName);
     System.out.println(", after a day of hiking you spot a silver cube.");
     System.out.println("The cube appears to be about 5 meters on each side.");
     System.out.println("You find a green door, open it and enter.");
     System.out.println("The door closes behind you with a soft whir and disappears.");
     System.out.println("There is a feel of mathematical magic in the air.");
     Keyboard.in.pause();
     return new Adventurer(playerName);
}
```


NO CHANGES

Program - Adventure 8.6

```
private void enterRoom(Adventurer adventurer) {
  /*
       The given adventurer has entered the
       first room.
  */
       Chest          chest;

       chest = new Chest();
       chest.display();
       chest.open(adventurer);
  }
```


NO CHANGES

Program - Adventure 8.7

```
  private void farewell(Adventurer adventurer) {
  /*
       Say farewell to the user and report the game result.
  */

       System.out.print("Congratulations ");
       System.out.print(adventurer.name());
       System.out.print(" you have left the game with ");
       System.out.print(adventurer.tokens());
       System.out.println(" tokens.");
  }
```


NEW

Program - Adventure 8.8

```
  private void makeDoor(Vector myRooms, int from, int to,
                        String color) {
  /*
       Make a Door from the Room with the given room number
       to the Room with the given room number in the given
       Vector of rooms. Use the given Door color.
  */
       Room fromRoom;
       Room toRoom;

       fromRoom = (Room) myRooms.elementAt(from - 1);
       toRoom = (Room) myRooms.elementAt(to - 1);
       fromRoom.makeDoor(toRoom, color);
  }
```


OLD

Class - Room 7.1

```
import java.util.*;
public class Room {
/*
   A room contains a treasure chest and some doors to adjoining rooms.
*/
/* Constructor */
   public Room(int anInt) {
   /*
        Initialize me so that I have the given room number,
        contain a treasure chest, and no doors.
   */
        this.number = anInt;
        this.chest = new Chest();
   }
```

Class - Room 8.1

NEW

```
import java.util.*;
public class Room {
/* A room contains a treasure chest and some doors to adjoining rooms.
   */
/* Constructor */
   public Room(int anInt) {
   /*
        Initialize me so that I have the given room number,
        contain a treasure chest, and no doors.
   */
        this.number = anInt;
        this.chest = new Chest();
        this.doors = new Vector();
   }
```


Class - Room 8.2

NO CHANGES

```
/* Instance Methods */
   public Room enter(Adventurer adventurer) {
   /*Describe myself, display a list of options, and
        perform the selected option. If the user selected
        quit then return null. If the user selected to go
        to another Room then return that Room. Otherwise
        return this Room. */
        TextMenu      menu;
        String  action;
        this.display();
        menu = this.buildMenu();
        action = menu.launch();
        return this.performAction(action, adventurer);
   }
```


Class - Room 8.2a

NEW

```
   public void makeDoor(Room aRoom, String color) {
   /*
        Make a door of the given color and place it between
        me and the given Room.
   */
        Door door;

        door = new Door(color, this, aRoom);
        this.doors.addElement(door);
        aRoom.doors.addElement(door);
   }
```


Class - Room 7.3

OLD

```
/* Private Instance Variables */
   private Chest        chest;
   private int   number;
/* Private Instance Methods */
   private void display() {
   /*
        Output a description of myself.
   */
        this.displayBasic();
        this.displayDoors();
        if (this.chest != null)
                this.chest.display();
   }
```


Class - Room 8.3

NEW

```
/* Private Instance Variables */
   private Chest        chest;
   private int   number;
   private Vector       doors;
/* Private Instance Methods */
   private void display() {
   /*
        Output a description of myself.
   */
        this.displayBasic();
        this.displayDoors();
        if (this.chest != null)
                this.chest.display();
   }
```


Class - Room 8.4

NO CHANGES

```
   private void displayBasic() {
   /*
        Output a basic description of myself that is
        independent of my doors and contents.
   */
        System.out.println();
        System.out.println("You are in a cubic room, 5 meters on each side.");
        System.out.println("A soft yellow glow illuminates the room.");
        System.out.println("The walls are made of a silver metal.");
        System.out.print("There is a large number ");
        System.out.print(this.number);
        System.out.println(" painted on one wall.");
   }
```

OLD

Class - Room 7.5

```
private void displayDoors() {
/*
      Output a description of all of my doors.
*/
}
```


NEW

Class - Room 8.5

```
private void displayDoors() {
/*
      Output a description of all of my doors.
*/
      Door    door;
      int     index;

      for (index = 0; index < this.doors.size(); index++){
            door = (Door) this.doors.elementAt(index);
            door.display();
      }
}
```


OLD

Class - Room 7.6

```
private TextMenu buildMenu() {
/*
      Create and answer a TextMenu containing the user's
      valid actions.
*/
      TextMenu      menu;

      menu = new TextMenu();
      menu.add("Quit");
      if (this.chest != null)
            menu.add("Open the chest.");
      // Add door choices here
      return menu;
}
```


NEW

Class - Room 8.6

```
private TextMenu buildMenu() {
/*    Create and answer a TextMenu containing the user's
      valid actions. */
      TextMenu      menu;
      int           index;
      Door          door;
      menu = new TextMenu();
      menu.add("Quit");
      if (this.chest != null)
        menu.add("Open the chest.");
      for (index = 0; index < this.doors.size(); index++){
        door = (Door) this.doors.elementAt(index);
        menu.add("Open the " + door.color() + " door.");
      }
      return menu;
}
```


OLD

Class - Room 7.7

```
private Room performAction(String action, Adventurer adventurer) {
/*    Perform the action described by the given String for
      the given Adventurer. Return the room the user
      selected, null if the user selected quit and this
      room if the user selected to open the chest. */
      if (action.equals("Open the chest.")) {
            this.chest.open(adventurer);
            this.chest = null;
            return this;
      }
      if (action.equals("Quit"))
            return null;
      return null;
}
}
```


NEW

Class - Room 8.7

```
private Room performAction(String action, Adventurer adventurer) {
/*    Perform the action described by the given String for
      the given Adventurer. Return the room the user
      selected, null if the user selected quit and this
      room if the user selected to open the chest.
*/
      if (action.equals("Open the chest.")) {
            this.chest.open(adventurer);
            this.chest = null;
            return this;
      }
      if (action.equals("Quit"))
            return null;
      return this.getRoomForAction(action);
      }
}
```

Class - Room 8.8

NEW

```
private Room getRoomForAction(String action) {
/*      Return the Room that I am connected to that is
        represented by the given action String. If no such
        Door exists, return me.
*/
        int             index;
        String  color;
        Door            door;
        color = action.substring(9, action.length() - 6);
        for (index = 0; index < this.doors.size(); index++){
                door = (Door) this.doors.elementAt(index);
                if (color.equals(door.color()))
                        return door.adjoiningRoom(this);
        }
        return this;
}
```

"Open the blue door."

0 9 length() - 6

Class - Door 8.1

```
public class Door {
/*
   An instance of this class represents a door in the Adventure game. A
   Door has a color and it connects two rooms.
*/
/* Constructor */
   public Door(String color, Room aRoom, Room bRoom) {
   /*
        Initialize me so that I have the given color and
        connect the given two Rooms.
   */
        this.color = color;
        this.room1 = aRoom;
        this.room2 = bRoom;
   }
```


Class - Door 8.2

```
/* Instance Methods */
   public void display() {
   /* Output a description of myself. */
        System.out.print("There is a ");
        System.out.print(this.color);
        System.out.println(" door in one wall.");
   }

   public String color() {
   /*
        Answer a String representing my color.
   */
        return this.color;
   }
```


Class - Door 8.3

```
   public Room adjoiningRoom(Room aRoom) {
   /*
        Answer the room that I connect the given Room to, or
        null if I don't connect it to any Room.
   */

        if (this.room1 == aRoom)
                return this.room2;
        else if (this.room2 == aRoom)
                return this.room1;
        else
                return null;
   }
```


Class - Door 8.4

```
/* Private Instance Variables */

   private String       color;
   private Room         room1;
   private Room         room2;

}
```


Class - TextMenu 7.1

OLD

```
import java.io.*;
import java.util.*;
public class TextMenu {
/* An instance of this class displays a list of strings for the user and
   allows the user to pick one. For now, up to
   five entries are supported. */
/* Contructor */

   public TextMenu() {
   /*
        Initialize me with no entries.
   */
        this.size = 0;
   }
```

Class - TextMenu 8.1

NEW

```
import java.io.*;
import java.util.*;
public class TextMenu {
/*
   An instance of this class displays a list of strings for the user and
   allows the user to pick one.
*/
/* Constructor */

   public TextMenu() {
   /*
        Initialize me with no entries.
   */
        this.entries = new Vector();
   }
```


Class - TextMenu 7.2

OLD

```
/* Instance Methods */
   public void add(String entry) {
   /*   Add the given String to me as my next choice. */
        this.size = this.size + 1;
        if (entry1 == null) {
                this.entry1 = entry;
                return;
        }
        if (entry2 == null) {
                this.entry2 = entry;
                return;
        }
   //more of the same for entries 3, 4 and 5.
   }
```


NEW

Class - TextMenu 8.2

```
/* Instance Methods */
   public void add(String entry) {
   /*
        Add the given String to me as my next choice.
   */
        this.entries.addElement(entry);
   }
```


OLD

Class - TextMenu 7.3

```
public String launch() {
/*
     Display myself and answer the String entry selected
     by the user.
*/
     String  action;
     int             index;

     index = this.getUserSelection();
```


DELETED

Class - TextMenu 7.4

```
     switch (index) {
             case 1: action = this.entry1; break;
             case 2: action = this.entry2; break;
             case 3: action = this.entry3; break;
             case 4: action = this.entry4; break;
             case 5: action = this.entry5; break;
             default: action = "";
     }
     return action;
}
```


NEW

Class - TextMenu 8.3

```
public String launch() {
/*
     Display myself and answer the String entry selected
     by the user.
*/
     String  action;
     int             index;

     index = this.getUserSelection();
     action = (String) this.entries.elementAt(index - 1);
     return action;
}
```

OLD

Class - TextMenu 7.5

```
/* Private Instance Variables */

   private String entry1;
   private String entry2;
   private String entry3;
   private String entry4;
   private String entry5;
   private int size;

/* Private Instance Methods */
```


NEW

Class - TextMenu 8.5

```
/* Private Instance Variables */

   private Vector entries;

/* Private Instance Methods */
```


Class - TextMenu 7.6

OLD

```
   private void display() {
   /*
        Display myself on the screen.
   */
        String  entry;
        int             index;
        System.out.println();
        System.out.println("Please type a number and press the Enter key:");
        if (this.entry1 != null) {
                System.out.print("1. ");
                System.out.println(this.entry1);
        }
        // same code for entry2, entry3, entry4 and entry5
   }
}
```


Class - TextMenu 8.6

NEW

```
   private void display() {
   /*
        Display myself on the screen.
   */
    String      entry;
    int index;
    System.out.println();
    System.out.println("Please type a number and press the Enter key:");
    for (index = 0; index < this.entries.size(); index++){
        entry = (String) this.entries.elementAt(index);
        System.out.print(index + 1);
        System.out.print(". ");;
        System.out.println(entry);
    }
   }
```


Class - TextMenu 8.7

NO CHANGE

```
   private int getUserSelection() {
   /*
        Query the user for an action and answer the index of
        the choice. If the user does not answer with a valid
        action, query again.
   */

        Integer choice;
        int             index;

        index = 0;
```


OLD

Class - TextMenu 7.8

```
   while ((index < 1) || (index > this.size)) {
        this.display();
        choice = Keyboard.in.readInteger();
        if (choice == null)
                index = 0;
        else
                index = choice.intValue();
   }
   return index;
```

Class - TextMenu 8.8

NEW

```
    while ((index < 1)||(index > this.entries.size())) {
        this.display();
        choice = Keyboard.in.readInteger();
        if (choice == null)
                index = 0;
        else
                index = choice.intValue();
    }
    return index;
  }
}
```


The Rest of the Classes are Omitted

- The rest of the classes are omitted to save space.
- See Lecture 16 and 15 for missing classes.