

CMSC 131: Chapter 15 (Supplement)

Arrays II

Arrays of Objects

Array of Objects: The base type of an array can be a class object.

Example: Array of Strings.

```
String[ ] greatCities = new String[5];
greatCities[2] = new String( "Paris" );
greatCities[0] = "Tokyo";
greatCities[4] = "Beltsville";
greatCities[1] = greatCities[2];
int k = 4;
int x = greatCities[k].length( );
char c = greatCities[2].charAt( 2 );
```

Arrays of Objects

Initializers: Array initializers can be used with class base types as well. The elements of the initializer can be **expressions** (not just constants).

Example: Array of **Strings**

```
String[ ] moreCities = { "New York", "Boston", "Kathmandu" };
```

Example: Initializing using a non-constant **expression**.

```
String[ ] cityState = {
    moreCities[0] + ", NY", moreCities[1] + ", MA" };
```

Example: Array of **Dates** (constructor is given month, day, year)

```
Date[ ] birthDays = {
    new Date( 2, 12, 1809 ), new Date( 2, 11, 1731 ) };
```

Command-Line Arguments

Dissecting main: Recall the main method declaration:

```
public static void main( String[ ] args ) ...
```

public: externally visible.

static: not associated with any one particular object instance.

void: returns no type.

String[] args: is called with an array of String command-line arguments. What are these arguments?

Command-Line Arguments: On Unix- and DOS-style systems, when a program is run from the command prompt, options are included on the command line. For example, the Unix command:

```
% emacs fooBar.java
```

runs the **emacs** program on the file **fooBar.java**. The string "**fooBar.java**" is a command-line argument to the program.

Command-Line Arguments

Command-Line Arguments: Provide a way for the user running your program to pass in run-time information.

- **run-time options:** affect how the program runs (e.g., run the program in "debug mode" with additional diagnostic output.)
- **I/O file names:** provide the names of files used for input and/or output.
- **special definitions:** define special values (e.g., paper size for a word processor).

Java Command Arguments:

- If you run Java directly from the **command prompt**, these arguments are typed right after the name of your Java program:

```
javac CommandArgTest.java          (compile your program)
java CommandArgTest -f foo -b bar  (run it)
```

Here "-f", "foo", "-b", "bar" are the (4) command-line arguments.

Command-Line Arguments: Eclipse

Java Command Arguments:

If you run Java from **Eclipse**, these arguments can be specified when you select "Run..." (rather than "Run As"). [Image omitted from notes]

Command-Line Arguments: Example

```
public class CommandArgTest {  
  
    public static void main(String[] args) {  
        System.out.println( "Command line arguments:" );  
        for ( int i = 0; i < args.length; i++)  
            System.out.println( " Argument[" + i + "] = " + args[i] );  
    }  
}
```

Command line arguments:

```
Argument[0] = -f  
Argument[1] = foo  
Argument[2] = -b  
Argument[3] = bar
```

Arrays as Instance Variables

We have discussed storing object references in an array. We can also have an array as an instance variable within a class object.

Example: Email manager. Consists of:

- **Helper class (EmailMessage)** stores:
 - **Address field** (e.g. "bob@yahoo.com") as a String
 - **Message body** as a String

- **State** (private data):
 - **Array of email messages** (msgs) of type EmailMessage, and
 - The **number** of current messages (nMsgs).

- **Behaviors** (public methods):
 - **Constructor** (given maximum number of allowed emails)
 - **Add** an email to the list
 - **Delete** an email from the list (given its index)
 - **Clear** the entire list
 - ... (and some others)

Email Manager: General Structure

EmailMessage: A helper class to store email addresses and bodies.

```
private String addr: email address
private String body: email body
```

MailManager: We utilize a **partially filled array**. We do not store values in all the entries, only in a specified number:

```
private EmailMessage[ ] msgs: Array of Email messages
private int nMsgs: Number of active messages
```

Email Manager: EmailMessage

EmailMessage: Stores a single email message. It provides the following public methods:

```
EmailMessage( String a, String b ): Standard constructor is given the address a and body b.
EmailMessage( EmailMessage e ): Copy constructor is given an email message e.
String toString( ): Converts to string.
    From: <john@notReal.com> Body: [Hi Everybody]
```

We omit the implementation details.

MailManager (Part 1)

MailManager: Stores the list of email messages and the current number of active messages. Let us investigate its various methods:

```
public MailManager( int max ): Constructor is given the maximum number of emails allowed. It
    allocates the array for the messages and sets the current number of messages to 0.
    msgs = new EmailMessage[max];
    nMsgs = 0;
```

```
public boolean isFull( ): This tests whether the email array is full.
    return ( nMsgs >= msgs.length );
```

```
public boolean addMsg( EmailMessage m ): Adds a given message to the end of the list (nMsgs)
    and increments the size (nMsgs++). If the list is full, it returns false, and otherwise it returns
    true.
    if ( isFull( ) ) return false;
    msgs[nMsgs++] = new EmailMessage( m );
    return true;
```

MailManager: Class Definition (Part 1)

```
public class MailManager {
    private EmailMessage[] msgs;           // the messages
    private int nMsgs;                     // current number of messages

    public MailManager( int max ) {
        msgs = new EmailMessage[max];
        nMsgs = 0;
    }

    public boolean isFull() { return ( nMsgs >= msgs.length ); }

    public boolean addMsg( EmailMessage m ) {
        if ( isFull() ) return false;
        msgs[nMsgs++] = new EmailMessage( m );
        return true;
    }
    // ... more to come ...
}
```

MailManager (Part 2)

MailManager: Next we consider the removal methods for deleting a single message and clearing the whole list.

```
public boolean deleteMsg( int d ) : This deletes a single email at index d. If d is out of range, we
return false. Otherwise, we eliminate the entry by sliding the subsequent emails down by one.
    for ( int j = d+1; j < nMsgs; j++ )
        msgs[j-1] = msgs[j];
    nMsgs--;
```

```
public void clear( ) : Clears the entire list.
    for ( int i = 0; i < nMsgs; i++ )
        msgs[i] = null;
    nMsgs = 0;
```

Q: Setting `nMsgs` to 0 would have been sufficient. Why go to the extra effort of setting them to `null`?

Ans: By unlinking them, we make it possible for the **garbage collector** to remove them.

MailManager: Class Definition (Part 2)

```
public class MailManager {
    private EmailMessage[ ] msgs;           // the messages
    private int nMsgs;                      // current number of messages

    // ... construct and add omitted ...

    public boolean deleteMsg( int d ) {
        if ( d < 0 || d > msgs.length ) return false;
        for ( int j = d+1; j < nMsgs; j++ )
            msgs[j-1] = msgs[j];
        nMsgs--;
        return true;
    }

    public void clear( ) {
        for ( int i = 0; i < nMsgs; i++ )
            msgs[i] = null;
        nMsgs = 0;
    }
    // ... more to come ...
}
```

MailManager (Part 3)

MailManager: Finally, consider **toString** and an accessor, **getMessages**, which returns an array of email messages.

public String toString() : Converts the messages into a string.

public EmailMessage[] getMessages() : Returns an array containing all the email messages.

```
    EmailMessage[ ] result = new EmailMessage[nMsgs];
    for ( int i = 0; i < nMsgs; i++ ) {
        result[i] = new EmailMessage( msgs[i] );
    }
    return result;
```

MailManager: Class Definition (Part 3)

```
public class MailManager {
    private EmailMessage[ ] msgs;           // the messages
    private int nMsgs;                       // current number of messages

    // ... prior methods omitted ...

    public String toString( ) {
        String result = "Mailbox: ";
        if ( nMsgs == 0 ) return result + "empty";
        for ( int i = 0; i < nMsgs; i++ )
            result = result + "\n " + msgs[i];
        return result;
    }

    public EmailMessage[ ] getMessages( ) {
        EmailMessage[ ] result = new EmailMessage[nMsgs];
        for ( int i = 0; i < nMsgs; i++ ) {
            result[i] = new EmailMessage( msgs[i] );
        }
        return result;
    }
}
```

MailManager: Sample Driver

```
public static void main( String[ ] args ) {

    MailManager myMail = new MailManager( 5 );

    myMail.addMsg( new EmailMessage( "john@notReal.com", "Hi Everybody" ) );
    myMail.addMsg( new EmailMessage( "rose@fantasy.com", "I hate spam" ) );

    System.out.println( myMail );

    myMail.addMsg( new EmailMessage( "pete@imaginary.com", "Me too" ) );
    myMail.deleteMsg( 0 );

    System.out.println( myMail );

    myMail.clear( );

    System.out.println( myMail );
}
```

Mailbox:
From: <john@notReal.com> Body: [Hi Everybody]
From: <rose@fantasy.com> Body: [I hate spam]

Mailbox:
From: <rose@fantasy.com> Body: [I hate spam]
From: <pete@imaginary.com> Body: [Me too]

Mailbox: empty

Deep/Shallow Copying and Privacy Leaks

Deep copying: Make a copy of **all** objects. This is what we implemented. This is **always safe** because changes to the copied data cannot affect the original object's integrity.

```
EmailMessage[ ] myMessages = myMail.getMessages( );

EmailMessage[ ] result = new EmailMessage[nMsgs];
for ( int i = 0; i < nMsgs; i++ )
    result[i] = new EmailMessage( msgs[i] );
```

Deep/Shallow Copying and Privacy Leaks

Very shallow copy: What if we just copy the array reference?

```
result = msgs;    // Shallow copy! Dangerous
return result;
```

There are two problems with this:

Minor problem: Gives the entire array, not just the current messages.

Major problem: We give the class user a **pointer directly to our private data** (msgs). Now they can do whatever they want to it! This is called a **privacy leak**: private data is directly accessible to the outside world.

Deep/Shallow Copying and Privacy Leaks

Half-deep copy: Copy the array, but do not copy the underlying objects.

```
EmailMessage[ ] result = new EmailMessage[nMsgs];
for ( int i = 0; i < nMsgs; i++ )
    result[i] = msgs[i];    // Shallow: Copies a pointer to msgs[i]
```

Not always bad: It is **harmless** if it is **not** possible to change the underlying objects (e.g., String). Otherwise it is **harmful**.

Classes that cannot be changed after creation are **immutable**.