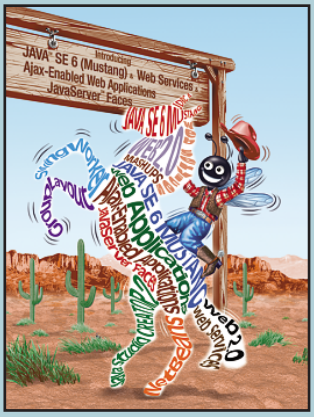
Using the Debugger



And so shall I catch the fly.
—William Shakespeare

We are built to make mistakes, coded for error.
—Lewis Thomas

What we anticipate seldom occurs; what we least expect generally happens.
—Benjamin Disraeli

He can run but he can't hide.
—Joe Louis

It is one thing to show a man that he is in error, and another to put him in possession of truth.
—John Locke

OBJECTIVES

In this appendix you will learn:

- To set breakpoints to debug applications.
- To use the `run` command to run an application through the debugger.
- To use the `stop` command to set a breakpoint.
- To use the `cont` command to continue execution.
- To use the `print` command to evaluate expressions.
- To use the `set` command to change variable values during program execution.
- To use the `step`, `step up` and `next` commands to control execution.
- To use the `watch` command to see how a field is modified during program execution.
- To use the `clear` command to list breakpoints or remove a breakpoint.

Outline

Q.1 Introduction

In Chapter 2, you learned that there are two types of errors—syntax errors and logic errors—and you learned how to eliminate syntax errors from your code. Logic errors do not prevent the application from compiling successfully, but they do cause an application to produce erroneous results when it runs. The JDK 5.0 includes software called a **debugger** that allows you to monitor the execution of your applications so you can locate and remove logic errors. The debugger will be one of your most important application development tools. Many IDEs provide their own debuggers similar to the one included in the JDK or provide a graphical user interface to the JDK's debugger.

This appendix demonstrates key features of the JDK's debugger using command-line applications that receive no input from the user. The same debugger features discussed here can be used to debug applications that take user input, but debugging such applications requires a slightly more complex setup. To focus on the debugger features, we have opted to demonstrate the debugger with simple command-line applications involving no user input. You can also find more information on the Java debugger at `java.sun.com/javase/6/docs/tooldocs/windows/jdb.html`.

Q.2 Breakpoints and the `run`, `stop`, `cont` and `print` Commands

We begin our study of the debugger by investigating **breakpoints**, which are markers that can be set at any executable line of code. When application execution reaches a breakpoint, execution pauses, allowing you to examine the values of variables to help determine whether logic errors exist. For example, you can examine the value of a variable that stores the result of a calculation to determine whether the calculation was performed correctly. Note that setting a breakpoint at a line of code that is not executable (such as a comment) causes the debugger to display an error message.

To illustrate the features of the debugger, we use application `AccountTest` (Fig. Q.1), which creates and manipulates an object of class `Account` (Fig. 3.13). Execution of `AccountTest` begins in `main` (lines 7–24). Line 9 creates an `Account` object with an initial balance of $50.00. Recall that `Account`'s constructor accepts one argument, which specifies the `Account`'s initial `balance`. Lines 12–13 output the initial account balance using `Account` method `getBalance`. Line 15 declares and initializes a local variable `depositAmount`. Lines 17–19 then print `depositAmount` and add it to the `Account`'s `balance` using

its `credit` method. Finally, lines 22–23 display the new `balance`. [*Note:* The Appendix Q examples directory contains a copy of `Account.java` identical to the one in Fig. 3.13.]

In the following steps, you will use breakpoints and various debugger commands to examine the value of the variable `depositAmount` declared in `AccountTest` (Fig. Q.1).

1. ***Opening the* Command Prompt *window and changing directories.*** Open the **Command Prompt** window by selecting **Start > Programs > Accessories > Command Prompt**. Change to the directory containing the appendix's examples by typing `cd C:\examples\debugger` [*Note:* If your examples are in a different directory, use that directory here.]
2. ***Compiling the application for debugging.*** The Java debugger works only with `.class` files that were compiled with the `-g` compiler option, which generates information that is used by the debugger to help you debug your applications. Compile the application with the `-g` command-line option by typing `javac -g AccountTest.java Account.java`. Recall from Chapter 2 that this command compiles both `AccountTest.java` and `Account.java`. The command `java -g *.java` compiles all of the working directory's `.java` files for debugging.

```
1  // Fig. N.1: AccountTest.java
2  // Create and manipulate an Account object.
3
4  public class AccountTest
5  {
6     // main method begins execution
7     public static void main( String args[] )
8     {
9        Account account = new Account( 50.00 ); // create Account object
10
11       // display initial balance of Account object
12       System.out.printf( "initial account balance: $%.2f\n",
13          account.getBalance() );
14
15       double depositAmount = 25.0; // deposit amount
16
17       System.out.printf( "\nadding %.2f to account balance\n\n",
18          depositAmount );
19       account.credit( depositAmount ); // add to account balance
20
21       // display new balance
22       System.out.printf( "new account balance: $%.2f\n",
23          account.getBalance() );
24    } // end main
25
26 } // end class AccountTest
```

```
initial account balance: $50.00

adding 25.00 to account balance

new account balance: $75.00
```

Fig. Q.1 | `AccountTest` class creates and manipulates an `Account` object.

3. ***Starting the debugger.*** In the **Command Prompt**, type `jdb` (Fig. Q.2). This command will start the Java debugger and enable you to use its features. [*Note:* We modified the colors of our **Command Prompt** window to allow us to highlight in yellow the user input required by each step.]
4. ***Running an application in the debugger.*** Run the `AccountTest` application through the debugger by typing `run AccountTest` (Fig. Q.3). If you do not set any breakpoints before running your application in the debugger, the application will run just as it would using the `java` command.
5. ***Restarting the debugger.*** To make proper use of the debugger, you must set at least one breakpoint before running the application. Restart the debugger by typing `jdb`.
6. ***Inserting breakpoints in Java.*** You set a breakpoint at a specific line of code in your application. The line numbers used in these steps are from the source code in Fig. Q.1. Set a breakpoint at line 12 in the source code by typing `stop at AccountTest:12` (Fig. Q.4). The **stop command** inserts a breakpoint at the line number specified after the command. You can set as many breakpoints as necessary. Set another breakpoint at line 19 by typing `stop at AccountTest:19` (Fig. Q.4). When the application runs, it suspends execution at any line that contains a breakpoint. The application is said to be in **break mode** when the debugger pauses the application's execution. Breakpoints can be set even after the debugging process has begun. Note that the debugger command `stop in`, followed by a class name, a period and a method name (e.g., `stop in Account.credit`) instructs the debugger to set a breakpoint at the first executable statement in the specified method. The debugger pauses execution when program control enters the method.

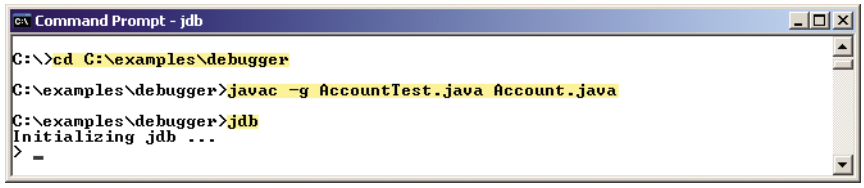


Fig. Q.2 | Starting the Java debugger.

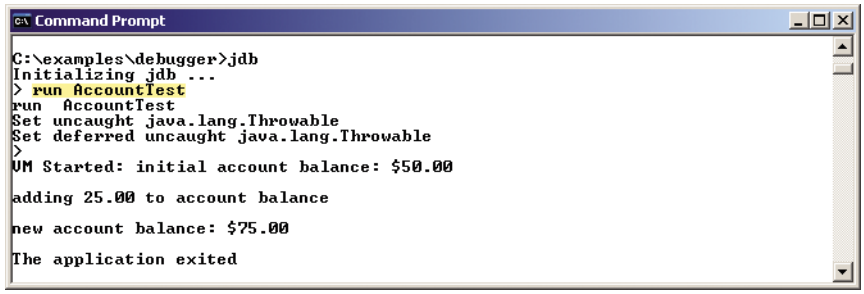


Fig. Q.3 | Running the `AccountTest` application through the debugger.

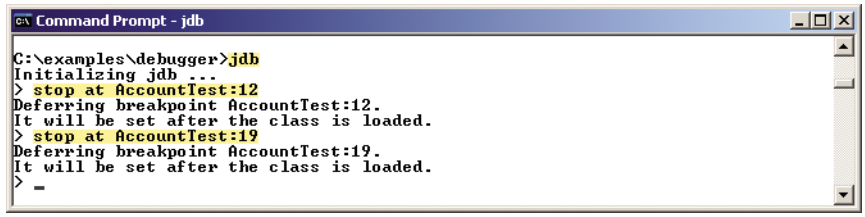


Fig. Q.4 | Setting breakpoints at lines 12 and 19.

7. ***Running the application and beginning the debugging process.*** Type `run AccountTest` to execute your application and begin the debugging process (Fig. Q.5). Note that the debugger prints text indicating that breakpoints were set at lines 12 and 19. The debugger calls each breakpoint a "deferred breakpoint" because each was set before the application began running in the debugger. The application pauses when execution reaches the breakpoint on line 12. At this point, the debugger notifies you that a breakpoint has been reached and it displays the source code at that line (12). That line of code is the next statement that will execute.
8. ***Using the `cont` command to resume execution.*** Type `cont`. The **`cont` command** causes the application to continue running until the next breakpoint is reached (line 19), at which point the debugger notifies you (Fig. Q.6). Note that `AccountTest`'s normal output appears between messages from the debugger.
9. ***Examining a variable's value.*** Type `print depositAmount` to display the current value stored in the `depositAmount` variable (Fig. Q.7). The **`print` command** allows you to peek inside the computer at the value of one of your variables. This command will help you find and eliminate logic errors in your code. Note that the value displayed is `25.0`—the value assigned to `depositAmount` in line 15 of Fig. Q.1.
10. ***Continuing application execution.*** Type `cont` to continue the application's execution. There are no more breakpoints, so the application is no longer in break mode. The application continues executing and eventually terminates (Fig. Q.8). The debugger will stop when the application ends.

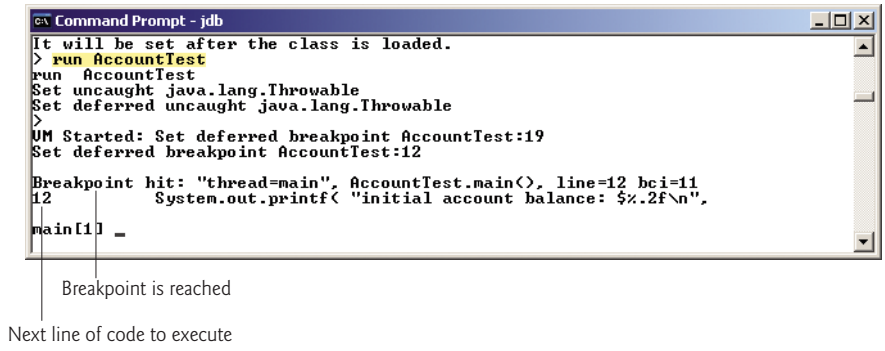


Fig. Q.5 | Restarting the `AccountTest` application.

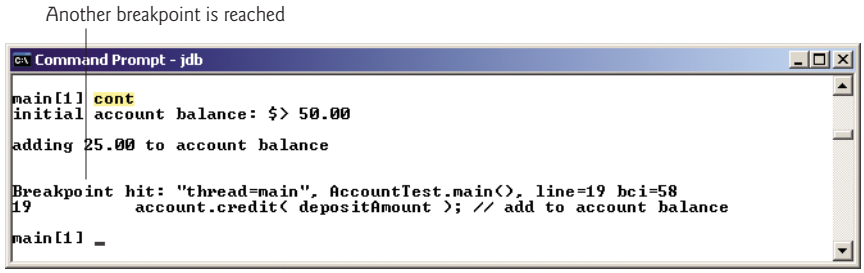


Fig. Q.6 | Execution reaches the second breakpoint.

Fig. Q.7 | Examining the value of variable `depositAmount`.

Fig. Q.8 | Continuing application execution and exiting the debugger.

In this section, you learned how to enable the debugger and set breakpoints so that you can examine variables with the `print` command while an application is running. You also learned how to use the `cont` command to continue execution after a breakpoint is reached.

Q.3 The `print` and `set` Commands

In the preceding section, you learned how to use the debugger's `print` command to examine the value of a variable during program execution. In this section, you will learn how to use the `print` command to examine the value of more complex expressions. You will also learn the **`set` command**, which allows the programmer to assign new values to variables.

For this section, we assume that you have followed *Step 1* and *Step 2* in Section Q.2 to open the **Command Prompt** window, change to the directory containing this appendix's examples (e.g., `C:\examples\debugger`) and compile the `AccountTest` application (and class `Account`) for debugging.

1. ***Starting debugging.*** In the **Command Prompt**, type `jdb` to start the Java debugger.
2. ***Inserting a breakpoint.*** Set a breakpoint at line 19 in the source code by typing `stop at AccountTest:19`.
3. ***Running the application and reaching a breakpoint.*** Type `run AccountTest` to begin the debugging process (Fig. Q.9). This will cause `AccountTest`'s `main` to execute until the breakpoint at line 19 is reached. This suspends application execution and switches the application into break mode. At this point, the statements in lines 9–13 created an `Account` object and printed the initial balance of

the `Account` obtained by calling its `getBalance` method. The statement in line 15 (Fig. Q.1) declared and initialized local variable `depositAmount` to `25.0`. The statement in line 19 is the next statement that will execute.

4. ***Evaluating arithmetic and boolean expressions.*** Recall from Section Q.2 that once the application has entered break mode, you can explore the values of the application's variables using the debugger's `print` command. You can also use the `print` command to evaluate arithmetic and `boolean` expressions. In the **Command Prompt** window, type `print depositAmount - 2.0`. Note that the `print` command returns the value `23.0` (Fig. Q.10). However, this command does not actually change the value of `depositAmount`. In the **Command Prompt** window, type `print depositAmount == 23.0`. Expressions containing the `==` symbol are treated as `boolean` expressions. The value returned is `false` (Fig. Q.10) because `depositAmount` does not currently contain the value `23.0`—`depositAmount` is still `25.0`.
5. ***Modifying values.*** The debugger allows you to change the values of variables during the application's execution. This can be valuable for experimenting with different values and for locating logic errors in applications. You can use the debugger's `set` command to change the value of a variable. Type `set depositAmount = 75.0`. The debugger changes the value of `depositAmount` and displays its new value (Fig. Q.11).

```
Command Prompt - jdb

C:\examples\debugger>jdb
Initializing jdb ...
> stop at AccountTest:19
Deferring breakpoint AccountTest:19.
It will be set after the class is loaded.
> run AccountTest
run  AccountTest
Set uncaught java.lang.Throwable
Set deferred uncaught java.lang.Throwable
>
VM Started: Set deferred breakpoint AccountTest:19
initial account balance: $50.00

adding 25.00 to account balance


Breakpoint hit: "thread=main", AccountTest.main(), line=19 bci=58
19          account.credit( depositAmount ); // add to account balance

main[1] _
```

Fig. Q.9 | Application execution suspended when debugger reaches the breakpoint at line 19.

```
Command Prompt - jdb

main[1] print depositAmount - 2.0
 depositAmount - 2.0 = 23.0
main[1] print depositAmount == 23.0
 depositAmount == 23.0 = false
main[1] _
```

Fig. Q.10 | Examining the values of an arithmetic and `boolean` expression.

```
Command Prompt - jdb

 depositAmount == 23.0 = false
main[1] set depositAmount = 75.0
 depositAmount = 75.0 = 75.0
main[1] _
```

Fig. Q.11 | Modifying values.

6. ***Viewing the application result.*** Type `cont` to continue application execution. Line 19 of `AccountTest` (Fig. Q.1) executes, passing `depositAmount` to `Account` method `credit`. Method `main` then displays the new balance. Note that the result is `$125.00` (Fig. Q.12). This shows that the preceding step changed the value of `depositAmount` from its initial value (`25.0`) to `75.0`.

In this section, you learned how to use the debugger's `print` command to evaluate arithmetic and `boolean` expressions. You also learned how to use the `set` command to modify the value of a variable during your application's execution.

Q.4 Controlling Execution Using the `step`, `step up` and `next` Commands

Sometimes you will need to execute an application line by line to find and fix errors. Walking through a portion of your application this way can help you verify that a method's code executes correctly. In this section, you will learn how to use the debugger for this task. The commands you learn in this section allow you to execute a method line by line, execute all the statements of a method at once or execute only the remaining statements of a method (if you have already executed some statements within the method).

Once again, we assume you are working in the directory containing this appendix's examples and have compiled for debugging with the `-g` compiler option.

1. ***Starting the debugger.*** Start the debugger by typing `jdb`.
2. ***Setting a breakpoint.*** Type `stop at AccountTest:19` to set a breakpoint at line 19.
3. ***Running the application.*** Run the application by typing `run AccountTest`. After the application displays its two output messages, the debugger indicates that the breakpoint has been reached and displays the code at line 19 (Fig. Q.13). The debugger and application then pause and wait for the next command to be entered.
4. ***Using the `step` command.*** The **`step` command** executes the next statement in the application. If the next statement to execute is a method call, control transfers to the called method. The `step` command enables you to enter a method and study the individual statements of that method. For instance, you can use the `print` and `set` commands to view and modify the variables within the method. You will now use the `step` command to enter the `credit` method of class `Account` (Fig. 3.13) by typing `step` (Fig. Q.14). The debugger indicates that the step has been completed and displays the next executable statement—in this case, line 21 of class `Account` (Fig. 3.13).

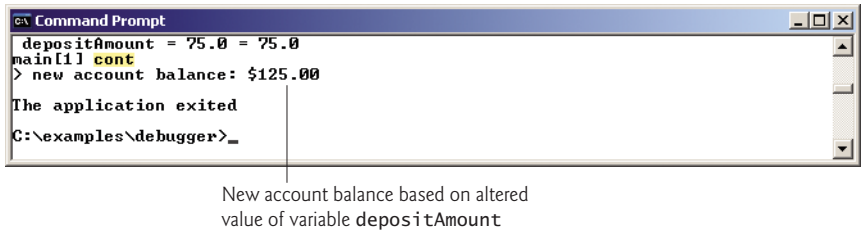


Fig. Q.12 | Output displayed after the debugging process.

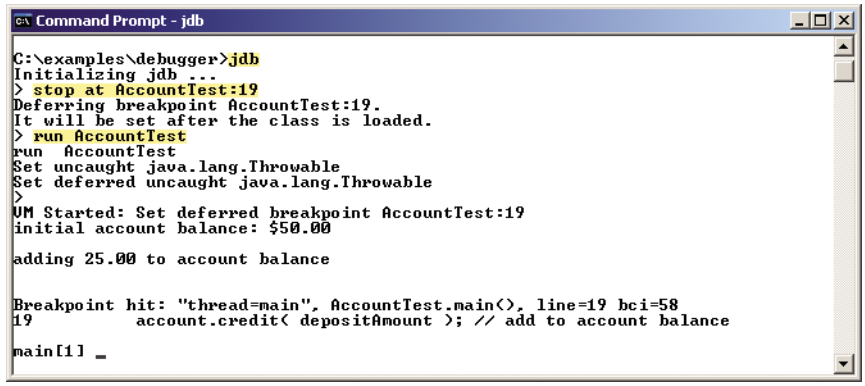


Fig. Q.13 | Reaching the breakpoint in the `AccountTest` application.

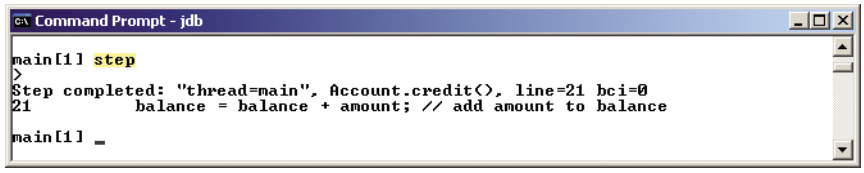


Fig. Q.14 | Stepping into the `credit` method.

5. ***Using the `step up` command.*** After you have stepped into the `credit` method, type `step up`. This command executes the remaining statements in the method and returns control to the place where the method was called. The `credit` method contains only one statement to add the method's parameter `amount` to instance variable `balance`. The `step up` command executes this statement, then pauses before line 22 in `AccountTest`. Thus, the next action to occur will be to print the new account balance (Fig. Q.15). In lengthy methods, you may want to look at a few key lines of code, then continue debugging the caller's code. The `step up` command is useful for situations in which you do not want to continue stepping through the entire method line by line.
6. ***Using the `cont` command to continue execution.*** Enter the `cont` command (Fig. Q.16) to continue execution. The statement at lines 22–23 executes, displaying the new balance, then the application and the debugger terminate.
7. ***Restarting the debugger.*** Restart the debugger by typing `jdb`.
8. ***Setting a breakpoint.*** Breakpoints persist only until the end of the debugging session in which they are set—once the debugger exits, all breakpoints are removed.

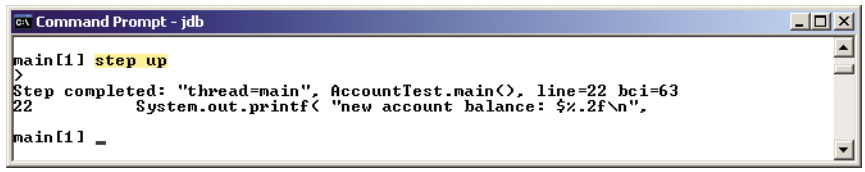


Fig. Q.15 | Stepping out of a method.

(In Section Q.6, you'll learn how to manually clear a breakpoint before the end of the debugging session.) Thus, the breakpoint set for line 19 in *Step 2* no longer exists upon restarting the debugger in *Step 7*. To reset the breakpoint at line 19, once again type `stop at AccountTest:19`.

9. ***Running the application.*** Type `run AccountTest` to run the application. As in *Step 3*, `AccountTest` runs until the breakpoint at line 19 is reached, then the debugger pauses and waits for the next command (Fig. Q.17).

10. ***Using the `next` command.*** Type `next`. This command behaves like the `step` command, except when the next statement to execute contains a method call. In that case, the called method executes in its entirety and the application advances to the next executable line after the method call (Fig. Q.18). Recall from *Step 4* that the `step` command would enter the called method. In this example, the `next` command causes `Account` method `credit` to execute, then the debugger pauses at line 22 in `AccountTest`.

Fig. Q.16 | Continuing execution of the `AccountTest` application.

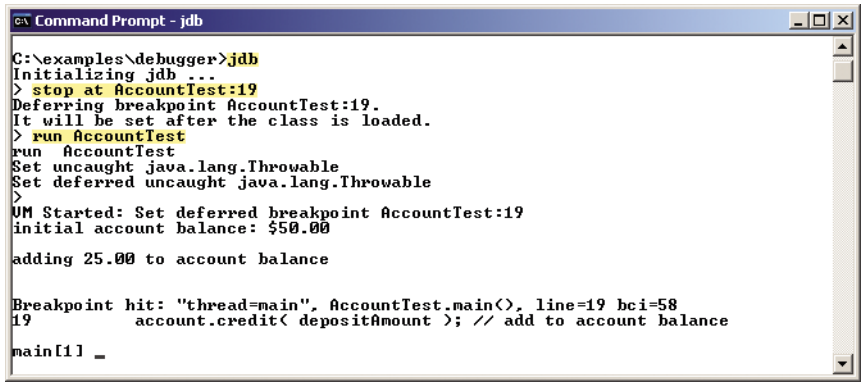


Fig. Q.17 | Reaching the breakpoint in the `AccountTest` application.

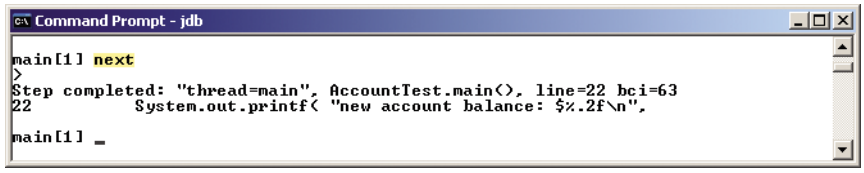


Fig. Q.18 | Stepping over a method call.

11. *Using the `exit` command.* Use the `exit` command to end the debugging session (Fig. Q.19). This command causes the `AccountTest` application to immediately terminate rather than execute the remaining statements in `main`. Note that when debugging some types of applications (e.g., GUI applications), the application continues to execute even after the debugging session ends.

In this section, you learned how to use the debugger's `step` and `step up` commands to debug methods called during your application's execution. You saw how the `next` command can be used to step over a method call. You also learned that the `exit` command ends a debugging session.

Q.5 The `watch` Command

In this section, we present the `watch` command, which tells the debugger to watch a field. When that field is about to change, the debugger will notify you. In this section, you will learn how to use the `watch` command to see how the `Account` object's field `balance` is modified during the execution of the `AccountTest` application.

As in the preceding two sections, we assume that you have followed *Step 1* and *Step 2* in Section Q.2 to open the **Command Prompt**, change to the correct examples directory and compile classes `AccountTest` and `Account` for debugging (i.e., with the `-g` compiler option).

1. *Starting the debugger.* Start the debugger by typing `jdb`.
2. *Watching a class's field.* Set a watch on `Account`'s `balance` field by typing `watch Account.balance` (Fig. Q.20). You can set a watch on any field during execution of the debugger. Whenever the value in a field is about to change, the debugger enters break mode and notifies you that the value will change. Watches can be placed only on fields, not on local variables.
3. *Running the application.* Run the application with the command `run AccountTest`. The debugger will now notify you that field `balance`'s value will change (Fig. Q.21). When the application begins, an instance of `Account` is created with an initial balance of $50.00 and a reference to the `Account` object is assigned to the local variable `account` (line 9, Fig. Q.1). Recall from Fig. 3.13 that when the

Fig. Q.19 | Exiting the debugger.

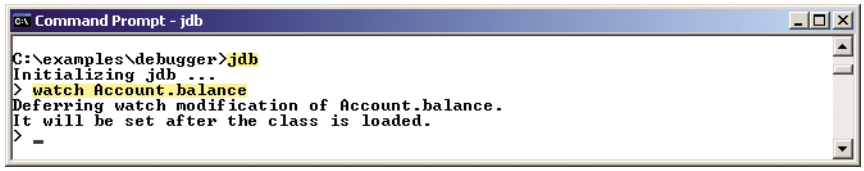


Fig. Q.20 | Setting a watch on `Account`'s `balance` field.

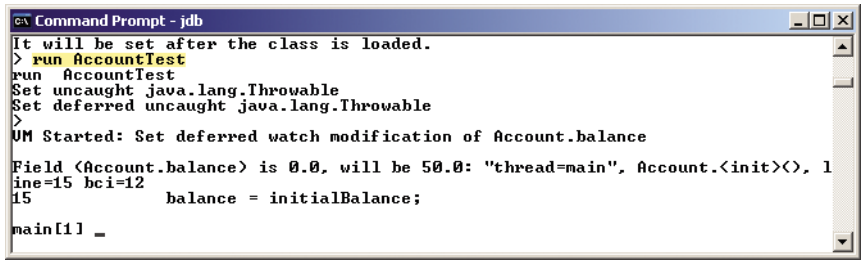


Fig. Q.21 | `AccountTest` application stops when `account` is created and its `balance` field will be modified.

constructor for this object runs, if parameter `initialBalance` is greater than `0.0`, instance variable `balance` is assigned the value of parameter `initialBalance`. The debugger notifies you that the value of `balance` will be set to `50.0`.

4. ***Adding money to the account.*** Type `cont` to continue executing the application. The application executes normally before reaching the code on line 19 of Fig. Q.1 that calls `Account` method `credit` to raise the `Account` object's `balance` by a specified `amount`. The debugger notifies you that instance variable `balance` will change (Fig. Q.22). Note that although line 19 of class `AccountTest` calls method `credit`, it is line 21 in `Account`'s method `credit` that actually changes the value of `balance`.
5. ***Continuing execution.*** Type `cont`—the application will finish executing because the application does not attempt any additional changes to `balance` (Fig. Q.23).
6. ***Restarting the debugger and resetting the watch on the variable.*** Type `jdb` to restart the debugger. Once again, set a watch on the `Account` instance variable `balance` by typing the `watch Account.balance`, then type `run AccountTest` to run the application (Fig. Q.24).

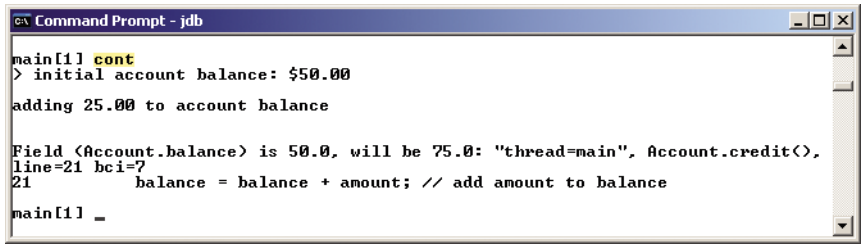


Fig. Q.22 | Changing the value of `balance` by calling `Account` method `credit`.

Fig. Q.23 | Continuing execution of `AccountTest`.

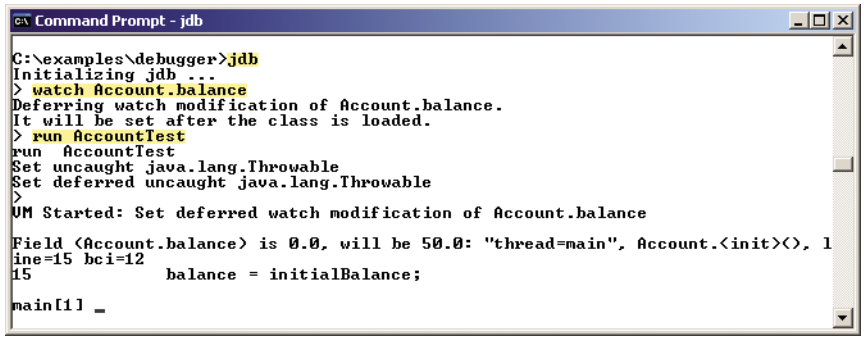


Fig. Q.24 | Restarting the debugger and resetting the watch on the variable `balance`.

7. *Removing the watch on the field.* Suppose you want to watch a field for only part of a program's execution. You can remove the debugger's watch on variable `balance` by typing `unwatch Account.balance` (Fig. Q.25). Type `cont`—the application will finish executing without reentering break mode.
8. *Closing the* **Command Prompt** *window.* Close the **Command Prompt** window by clicking its close button.

In this section, you learned how to use the `watch` command to enable the debugger to notify you of changes to the value of a field throughout the life of an application. You also learned how to use the `unwatch` command to remove a watch on a field before the end of the application.

Q.6 The `clear` Command

In the preceding section, you learned to use the `unwatch` command to remove a watch on a field. The debugger also provides the `clear` command to remove a breakpoint from an application. You will often need to debug applications containing repetitive actions, such as a loop. You may want to examine the values of variables during several, but possibly not all, of the loop's iterations. If you set a breakpoint in the body of a loop, the debugger will pause before each execution of the line containing a breakpoint. After determining that the loop is working properly, you may want to remove the breakpoint and allow the remaining iterations to proceed normally. In this section, we use the compound interest application in Fig. 5.6 to demonstrate how the debugger behaves when you set a breakpoint in the body of a `for` statement and how to remove a breakpoint in the middle of a debugging session.

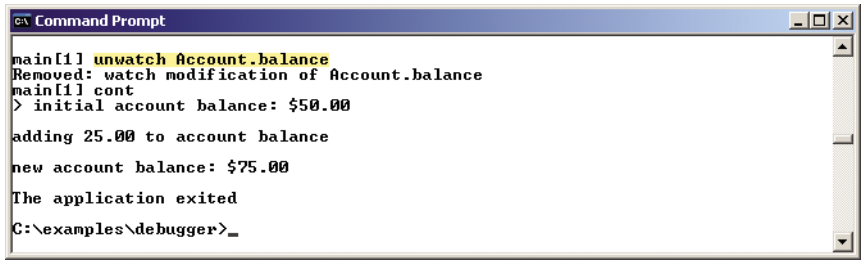


Fig. Q.25 | Removing the watch on variable `balance`.

1. ***Opening the* Command Prompt *window, changing directories and compiling the application for debugging.*** Open the **Command Prompt** window, then change to the directory containing this appendix's examples. For your convenience, we have provided a copy of the `Interest.java` file in this directory. Compile the application for debugging by typing `javac -g Interest.java`.
2. ***Starting the debugger and setting breakpoints.*** Start the debugger by typing `jdb`. Set breakpoints at lines 13 and 22 of class `Interest` by typing `stop at Interest:13`, then `stop at Interest:22` (Fig. Q.26).
3. ***Running the application.*** Run the application by typing `run Interest`. The application executes until reaching the breakpoint at line 13 (Fig. Q.27).
4. ***Continuing execution.*** Type `cont` to continue—the application executes line 13, printing the column headings `"Year"` and `"Amount on deposit"`. Note that line 13 appears before the `for` statement at lines 16–23 in `Interest` (Fig. 5.6) and thus executes only once. Execution continues past line 13 until the breakpoint at line 22 is reached during the first iteration of the `for` statement (Fig. Q.28).
5. ***Examining variable values.*** Type `print year` to examine the current value of variable `year` (i.e., the `for`'s control variable). Print the value of variable `amount` too (Fig. Q.29).
6. ***Continuing execution.*** Type `cont` to continue execution. Line 22 executes and prints the current values of `year` and `amount`. After the `for` enters its second iteration, the debugger notifies you that the breakpoint at line 22 has been reached a second time. Note that the debugger pauses each time a line where a breakpoint has been set is about to execute—when the breakpoint appears in a loop, the debugger pauses during each iteration. Print the values of variables `year` and `amount` again to see how the values have changed since the first iteration of the `for` (Fig. Q.30).

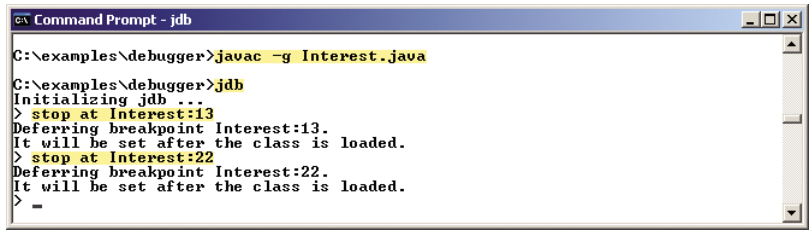


Fig. Q.26 | Setting breakpoints in the `Interest` application.

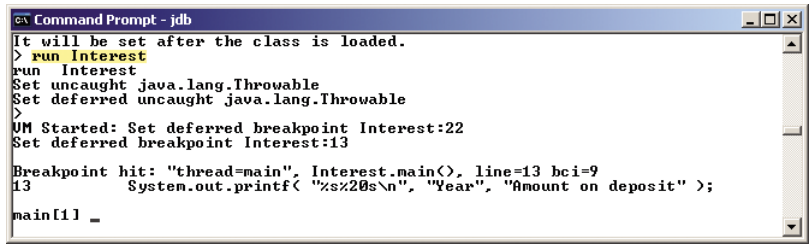


Fig. Q.27 | Reaching the breakpoint at line 13 in the `Interest` application.

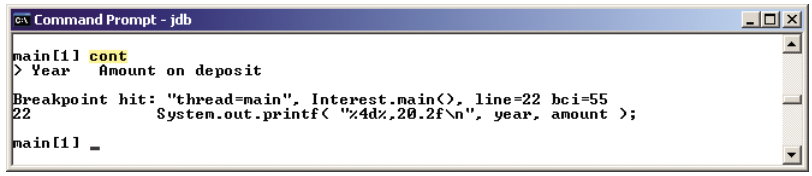


Fig. Q.28 | Reaching the breakpoint at line 22 in the `Interest` application.

Fig. Q.29 | Printing `year` and `amount` during the first iteration of `Interest`'s `for`.

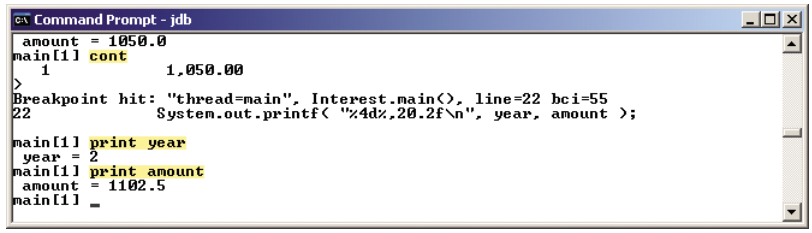


Fig. Q.30 | Printing `year` and `amount` during the second iteration of `Interest`'s `for`.

7. ***Removing a breakpoint.*** You can display a list of all of the breakpoints in the application by typing `clear` (Fig. Q.31). Suppose you are satisfied that the `Interest` application's `for` statement is working properly, so you want to remove the breakpoint at line 22 and allow the remaining iterations of the loop to proceed normally. You can remove the breakpoint at line 22 by typing `clear Interest:22`. Now type `clear` to list the remaining breakpoints in the application. The debugger should indicate that only the breakpoint at line 13 remains (Fig. Q.31). Note that this breakpoint has already been reached and thus will no longer affect execution.
8. ***Continuing execution after removing a breakpoint.*** Type `cont` to continue execution. Recall that execution last paused before the `printf` statement in line 22. If the breakpoint at line 22 was removed successfully, continuing the application will produce the correct output for the current and remaining iterations of the `for` statement without the application halting (Fig. Q.32).

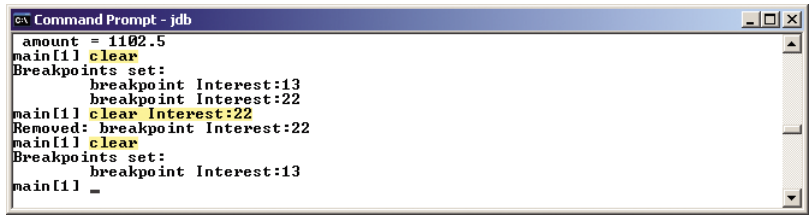


Fig. Q.31 | Removing the breakpoint at line 22.

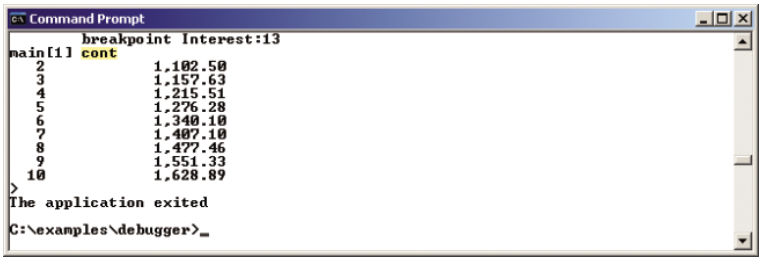


Fig. Q.32 | Application executes without a breakpoint set at line 22.

In this section, you learned how to use the `clear` command to list all the breakpoints set for an application and remove a breakpoint.

Q.7 Wrap-Up

In this appendix, you learned how to insert and remove breakpoints in the debugger. Breakpoints allow you to pause application execution so you can examine variable values with the debugger's `print` command. This capability will help you locate and fix logic errors in your applications. You saw how to use the `print` command to examine the value of an expression and how to use the `set` command to change the value of a variable. You also learned debugger commands (including the `step`, `step up` and `next` commands) that can be used to determine whether a method is executing correctly. You learned how to use the `watch` command to keep track of a field throughout the life of an application. Finally, you learned how to use the `clear` command to list all the breakpoints set for an application or remove individual breakpoints to continue execution without breakpoints.

Self-Review Exercises

Q.1 Fill in the blanks in each of the following statements:

a) A breakpoint cannot be set at a(n) _____.

b) You can examine the value of an expression by using the debugger's _____ command.

c) You can modify the value of a variable by using the debugger's _____ command.

d) During debugging, the _____ command executes the remaining statements in the current method and returns program control to the place where the method was called.

e) The debugger's _____ command behaves like the `step` command when the next statement to execute does not contain a method call.

f) The `watch` debugger command allows you to view all changes to a(n) _____.

Q.2 State whether each of the following is *true* or *false*. If *false*, explain why.

a) When application execution suspends at a breakpoint, the next statement to be executed is the statement after the breakpoint.

b) Watches can be removed using the debugger's `clear` command.

c) The `-g` compiler option must be used when compiling classes for debugging.

d) When a breakpoint appears in a loop, the debugger pauses only the first time that the breakpoint is encountered.

Answers to Self-Review Exercises

Q.1 a) comment. b) `print`. c) `set`. d) `step up`. e) `next`. f) field.

Q.2 a) False. When application execution suspends at a breakpoint, the next statement to be executed is the statement at the breakpoint. b) False. Watches can be removed using the debugger's `unwatch` command. c) True. d) False. When a breakpoint appears in a loop, the debugger pauses during each iteration.