CSC112 Spring 2011
Fundamentals of Computer Science
Lab 8 – Sorting and Debugging

Create a directory named Lab8. Keep all of your source and compiled programs in the directory Lab8.

In this lab we will do two things:

- Modify lab 7 to include sorting (by last name)
- Learn to use a symbolic debugger

Sorting

Extend your program from Lab 7 to sort the names (by last name) before printing the names and pay amount. Sorting by last name requires a way to compare two names. Use the library function `strcmp()` to compare names. You will need to include the header file:

```
#include <cstring>
```

in the header section of your program. Using `strcmp()` is illustrated in the following example:

```
int main()
{
    int u ;
    char * s1 = (char *) "cat" ;
    char * s2 = (char *) "dog" ;

    u = strcmp( s1, s2 ) ;
}
```

The function `strcmp` accepts two C-style character strings, `s1` and `s2`. It returns an integer as follows:

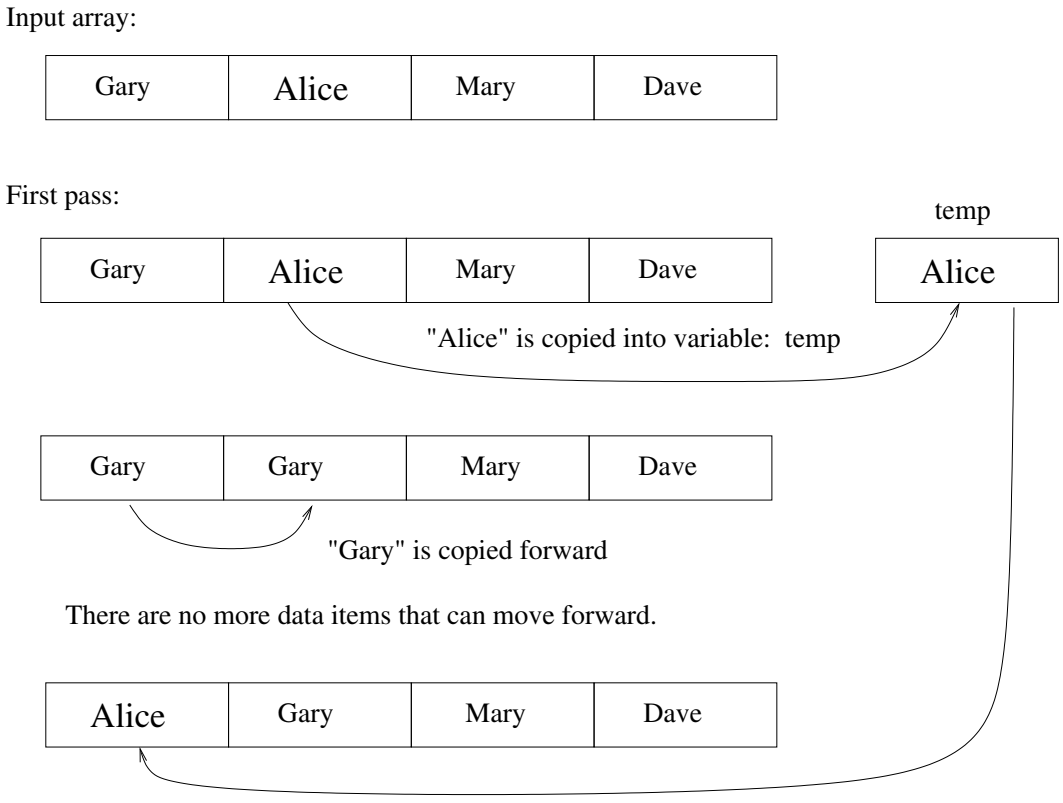
- Returns an integer less than zero if string `s1` comes alphabetically before `s2`
- Returns zero if string `s1` equals `s2`
- Returns an integer greater than zero if string `s1` comes alphabetically after `s2`

Use the method known as **insertion sort** to put the employee records in alphabetical order. A description of insertion sort is given below.[1]

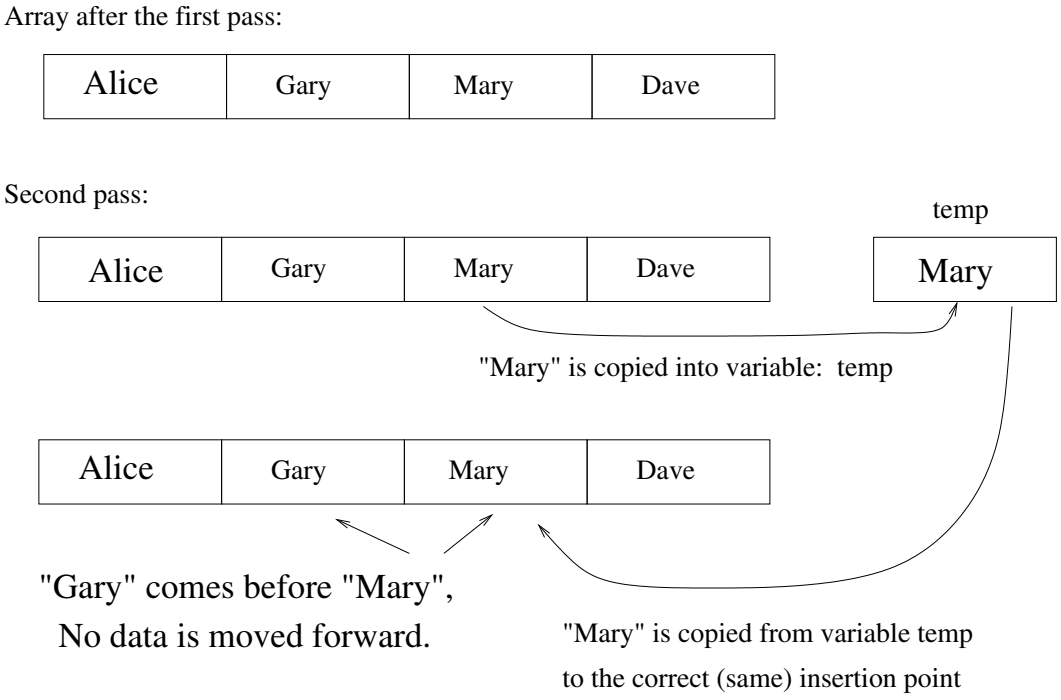
[1] One of the goals of this project is to further develop your ability to understand a description of an algorithm and create an implementation in C++.

For every data item in the array starting with position 1 do:
Insert the current data item in the correct position among the data items to the left of the current position. To accomplish this, copy the current data item to another variable, **temp**. Scan backwards through the array moving each data item forward until you discover a data item in position p that is less than the current data item, or until you discover that there are no more data items that can be moved forward ($p < 0$). Place the data item stored in the variable **temp** in position $p + 1$.

The steps of insertion sort are illustrated in the following sequence of diagrams. We start with the first pass of insertion sort.



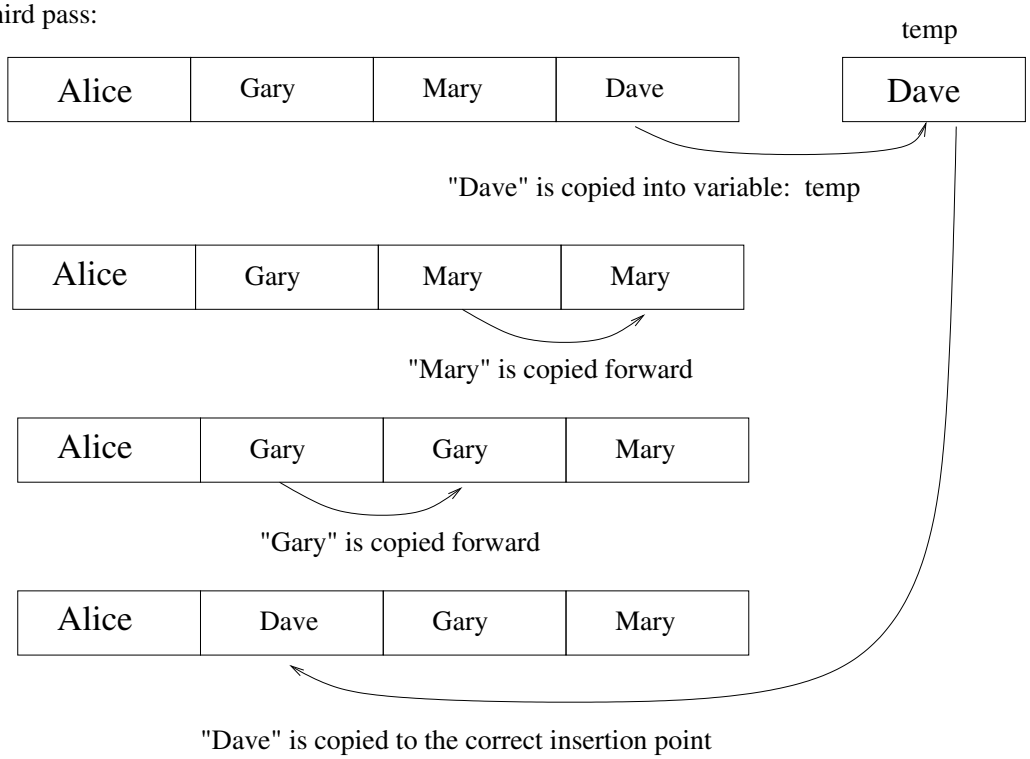
The second pass of insertion sort is illustrated below:



The third and final pass of insertion sort is illustrated below:

Array after the second pass:

Third pass:



Sorting is complete.

Using a Symbolic Debugger

A symbolic debugger is is a program to help you identify errors in your program. Symbolic debuggers are especially helpful for mysterious program failures such as "segmentation fault" and other run-time errors. Once you become familiar with using a symbolic debugger, you may find it *very* helpful for locating errors in your other projects.

A symbolic debugger reads your executable code (native machine instructions which are contained in the file named **a.out** by default), and steps through (executes) your program in a controlled manner.

The debugger can correlate positions in the executable code to lines of C++ source code through a special table which is included in the executable code file. If an error occurs (say, a segmentation fault), the symbolic debugger can show you the line of your C++ source code which caused the error. You can also set a "breakpoint" in your program. Execution will pause at the breakpoint, and allow you to examine the variables in your program at exactly that point in the execution of your program.

Data objects in your C++ source code are reduced to addresses in the executable code. There is a table in the executable program which also enables the debugger to correlate machine addresses to the variables which you have declared in your C++ source code. You can refer to variables **by name** in a running machine code program. Sweet.

But, there is one more important fact: the table(s) that enable the debugger to correlate executable code to C++ source code are not included in the executable code by default. A compiler option is necessary to instruct the compiler to include debugging tables in the compiler's output file. If our C++ source program is named "**lab8_example.cc**", then we need to use the following command to compile it for use with the debugger.

```
g++ -g lab8_example.cc
```

The symbolic debugger for Ubuntu is called **gdb**. You can use **gdb** from the command line, but it is much more convenient to use it through a graphical interface named **ddd**. Your default install of Ubuntu probably does not include **ddd**. To get **ddd**, open a terminal and use:

```
sudo apt-get install ddd
```

After installing `ddd`, proceed with the following steps.

1. Download the C++ program named "lab8_example.cc" from

   `http://menehune.opt.wfu.edu/CSC112`

2. Compile the C++ program using "g++ -g lab8_example.cc"

3. Run `ddd` on the executable. I.e., "ddd a.out". After a few seconds, two windows will open. The larger window is divided into two sub-windows. The upper sub-window shows your source code, and the lower sub-window shows a command line session with the underlying symbolic debugger (gdb). A second, much smaller window contains a control panel with action-buttons such as "Run", "Interrupt", "Step", etc.

4. For our first experiment, click on the "Run" button. The program will halt with a **Segmentation fault**.

   (a) On what line of code does the segmentation fault occur ?

   (b) What are the values of the local variables (all local variables) where the fault occurs ? *Hint: Place the cursor in the lower window at the* `(gdb)` *prompt and use the* `print` *command. For example,* `print i` *will print the value of the variable* `i`.

5. For our next experiment, you will set a breakpoint to pause the execution at a desired point. Place your cursor directly in front of the line of code in the main program that reads:

   ```
   r[j] = f(a,k)  ;
   ```

   and hold down the right mouse button. A pop-up menu should appear. Select "Set Breakpoint". At this point you should see a small red "Stop" sign in front of the statement. Go to the **Program** menu at the top of `ddd` and select "Run Again". You may notice that there are keyboard shortcuts for everything in the menus. As you get more experienced with `ddd`, feel free to try the shortcuts.

   (a) Using the `(gdb)` command line session, display the values of the local variables `j` and `k` at the breakpoint and make a note of them.

   (b) Use the "Cont" button to continue execution. Once again, find the values of `j` and `k`, and make a note of them.

   (c) Repeat step 5b until the segmentation fault occurs. *Hint: This will not take very long.*

   (d) What were the values of `j` and `k` just before the segmentation fault occurs.

Last question: Why does this program cause a segmentation fault ?

Turn in: Write a few sentences answering the questions in the steps above. Write your answers in a text file named **lab8.txt**.

Change to the directory containing the sub-directory "Lab8" Create a file named "lab8.tar" using the command:

```
tar cf lab8.tar Lab8
```

Upload the file "lab8.tar" to your account on telesto.