Lab 6

Each lab will begin with a recap of last lab and a brief demonstration by the TAs for the core concepts examined in this lab. As such, this document will not serve to tell you everything the TAs will in the demo. It is highly encouraged that you ask questions and take notes. In order to get credit for the lab, you need to be checked off by the end of lab. For non-zero labs, you can earn a maximum of 3 points for lab work completed outside of lab time, but you must finish the lab before the next lab. For extenuating circumstance, contact your lab TAs and Instructor.

(3 pts) Conditional Compilation/Include Safegaurds: One of the useful features of the preprocessor is to conditionally include code. For instance, this is often referred to as a DEBUG macro:

```
#ifdef DEBUG
/* your debug code here */
#endif

/* your non-debug code here*/
```

For this task, ensure that all of your print statements are wrapped in DEBUG macros. You can compile with a –D DEBUG to define it or leave it out. Select one file in Assignment 3 to add these debug statements to. Run the program with the DEBUG on to show your TA for points.

```
g++ prog.cpp –D DEBUG
```

(4 pts) GDB Refresh

Follow the outlined tutorial in the program shown. Demonstrate to your TAs that you can use all of the commands presented here.

The purpose of a debugger such as GDB is to allow you to see what is going on "inside" another program while it executes -- or what another program was doing at the moment it crashed.

GDB can do four main kinds of things (plus other things in support of these) to help you catch bugs in the act:

- Start your program, specifying anything that might affect its behavior.
- Make your program stop on specified conditions.
- Examine what has happened, when your program has stopped.
- Change things in your program, so you can experiment with correcting the effects of one bug and go on to learn about another.

GDB Manpage is a good source of information, i.e. man gdb.

The first thing you need to do to start debugging your program is to compile it with debugging symbols, this is accomplished with the -g flag:

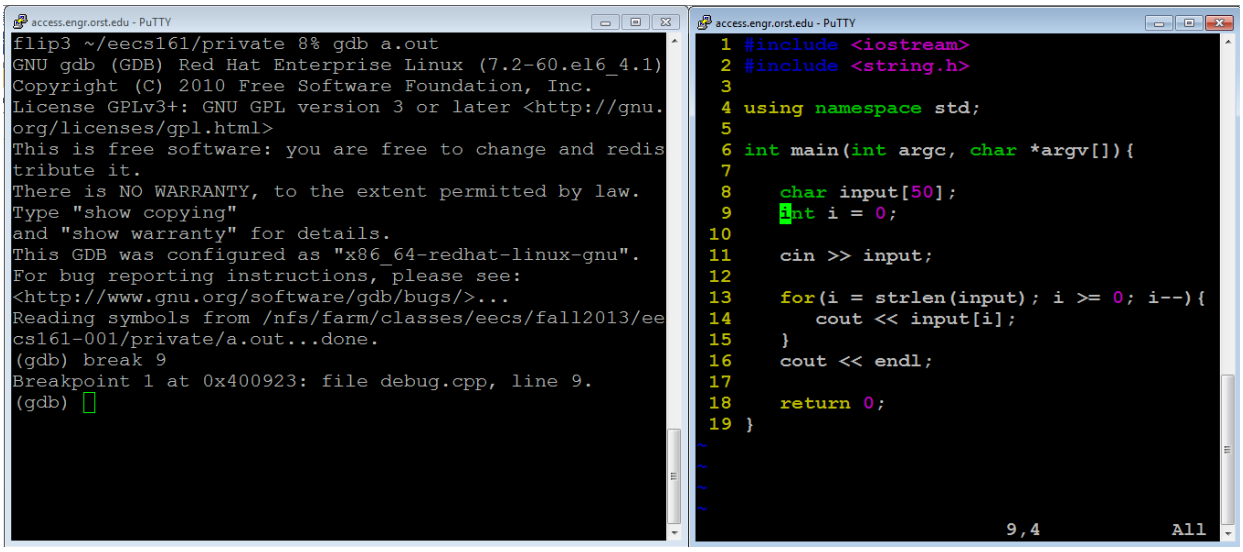
```
g++ filename.cpp -g -o filename
```

Lets start with a simple program that gets a line of text from the user, and prints it out backwards to the screen:

```
#include <iostream>
#include <string.h>

using namespace std;

int main(int argc, char *argv[]){
  char input[50];
  int i = 0;

  cin >> input;

  for(i = strlen(input); i >= 0; i--){
     cout << input[i];
  }
  cout << endl;

  return 0;
}
```

compile and start the debugger with:

```
g++ debug.cpp -g -o debug
gdb ./debug  (start another session which will run gdb)
```



Here is a mini tutorial for the 8 main commands that you will mostly be using in your debugging session

1. `break`
2. `run`
3. `print`
4. `next & step`
5. `continue`
6. `display & watch`
7. `where (or bt)`

1. The **break** Command:

gdb will remember the line numbers of your source file. This will let us easily set up break points in the program. A break point, is a line in the code where you want execution to pause. Once you pause execution you will be able to examine variables, and walk through the program, and other things of that nature.

Continuing with our example lets set up a break point at line 6, just before we declare int i = 0;

```
(gdb) break 9
Breakpoint 1 at 0x400923: file debug.cpp, line 9.
(gdb)
```

2. The **run** Command:

run will begin initial execution of your program. This will run your program as you normally would outside of the debugger, until it reaches a break point line. This means if you need to pass any command line arguments, you list them after run just as they would be listed after the program name on the command line.

At this moment, you will have been returned to the gdb command prompt. (Using run again after your program has been started, will ask to terminate the current execution and start over)

From our example:

```
Starting program: /nfs/farm/classes/eecs/fall2013/eecs161-001/private/a.out

Breakpoint 1, main (argc=1, argv=0x7fffffffd008)
    at debug.cpp:9
9           int i = 0;
```

3. The **print** Command:

print will let you see the values of data in your program. It takes an argument of the variable name.

In our example, we are paused right before we declare and initialize i. Let's look what the value of i is now:

```
(gdb) print i
$1 = -1075457232
(gdb)
```

i contains garbage, we haven't put anything into it yet.

4. The next and step Commands:

next and step do basically the same thing, step line by line through the program. The difference is that next steps over a function call, and step will step into it.

Now in our example, we will step to the beginning of the next instruction

```
(gdb) step
11      cin >> input;
(gdb)
```

before we execute the cin, let's check the value of i again:

```
(gdb) print i
$2 = 0
(gdb)
```

i is now equal to 0, like it should be.

Now, let's use next to move into the cin statement:

```
(gdb) next
```

What happened here? We weren't returned to the gdb prompt. Well the program is inside cin, waiting for us to input something.

Input string here, and press enter.

5. The continue Command

continue will pick up execution of the program after it has reached a break point.

Let's continue to the end of the program now:

```
(gdb) continue
```

```
Continuing.
olleh

Program exited normally.
(gdb)
```

Here we've reached the end of our program, you can see that it printed in reverse "input", which is what was fed to cin.

6. The display and watch Commands:

display will show a variable's contents at each step of the way in your program. Let's start over in our example. Delete the breakpoint at line 6

```
(gdb) del break 1
```

This deletes our first breakpoint at line 9. You can also clear all breakpoints w/ clear.

Now, let's set a new breakpoint at line 14, the cout statement inside the for loop

```
(gdb) break 14
Breakpoint 2 at 0x40094c: file debug.cpp, line 14.
(gdb)
```

Run the program again, and enter the input. When it returns to the gdb command prompt, we will display input[i] and watch it through the for loop with each next or breakpoint.

```
Breakpoint 2, main (argc=1, argv=0x7fffffffd008)
    at debug.cpp:14
14            cout << input[i];
(gdb) display input[i]
1: input[i] = 0 '\0'
(gdb) next
13      for(i=strlen(input);i>=0;i--) {
1: input[i] = 0 '\0'
(gdb) next

Breakpoint 2, main (argc=1, argv=0x7fffffffd008)
    at debug.cpp:14
14            cout << input[i];
1: input[i] = 111 'o'
(gdb) next
13      for(i=strlen(input);i>=0;i--) {
1: input[i] = 111 'o'
(gdb) next
```

Here we stepped through the loop, always looking at what input[i] was equal to.

We can also watch a variable, which allows us to see the contents at any point when the memory changes.

```
(gdb) watch input
Watchpoint 2: input
(gdb) continue
Continuing.
hello
Watchpoint 2: input

Old value =
"\030\320\377\377\377\177\000\000\065\n@\000\000\000\000\000\210\373\240\031\
065\000\000\000\360\t@", '\000' <repeats 13 times>,
"0\b@\000\000\000\000\000\000", <incomplete sequence \320>
New value =
"h\320\377\377\377\177\000\000\065\n@\000\000\000\000\000\210\373\240\031\065
\000\000\000\360\t@", '\000' <repeats 13 times>,
"0\b@\000\000\000\000\000\000", <incomplete sequence \320>
0x000000352067b82a in std::basic_istream<char, std::char_traits<char> >&
std::operator>><char, std::char_traits<char> >(std::basic_istream<char,
std::char_traits<char> >&, char*) () from /usr/lib64/libstdc++.so.6

(gdb) continue
Continuing.
Watchpoint 2: input

Old value =
"h\320\377\377\377\177\000\000\065\n@\000\000\000\000\000\210\373\240\031\065
\000\000\000\360\t@", '\000' <repeats 13 times>,
"0\b@\000\000\000\000\000\000", <incomplete sequence \320>
New value =
"he\377\377\377\177\000\000\065\n@\000\000\000\000\000\210\373\240\031\065\00
0\000\000\360\t@", '\000' <repeats 13 times>, "0\b@\000\000\000\000\000\000",
<incomplete sequence \320>
0x000000352067b82a in std::basic_istream<char, std::char_traits<char> >&
std::operator>><char, std::char_traits<char> >(std::basic_istream<char,
std::char_traits<char> >&, char*) () from /usr/lib64/libstdc++.so.6
```

7. The where (or bt) Command

The where (or bt) command prints a backtrace of all stack frames. This may not make much sense but it is useful in seeing where our program crashes.

Let's modify our program just a little so that it will crash:

```
#include <iostream>
#include <string.h>

using namespace std;

int main(int argc, char *argv[]){
	char *input = NULL;
	int i = 0;

	cin >> input;
```

```
        for(i = strlen(input); i >= 0; i--){
           cout << input[i];
        }
        cout << endl;

        return 0;
}
```

Here we've changed input to be a pointer to a char and set it to NULL to make sure it doesn't point anywhere until we set it. Recompile and run gdb on it again to see what happens when it crashes.

```
(gdb) r
Starting program: /nfs/farm/classes/eecs/fall2013/eecs161-001/private/a.out
hello

Program received signal SIGSEGV, Segmentation fault.
0x000000352067b826 in std::basic_istream<char, std::char_traits<char> >&
std::operator>><char, std::char_traits<char> >(std::basic_istream<char,
std::char_traits<char> >&, char*) () from /usr/lib64/libstdc++.so.6

(gdb) where
#0  0x000000352067b826 in std::basic_istream<char, std::char_traits<char> >&
std::operator>><char, std::char_traits<char> >(std::basic_istream<char,
std::char_traits<char> >&, char*) () from /usr/lib64/libstdc++.so.6
#1  0x0000000000400943 in main (argc=1,
    argv=0x7fffffffd008) at debug.cpp:11

(gdb)
```

We see at the bottom, two frames. #1 is the top most frame and shows where we crashed. Use the up command to move up the stack.

```
(gdb) up
#1  0x0000000000400943 in main (argc=1,
    argv=0x7fffffffd008) at debug.cpp:11
11          cin >> input;

(gdb)
```

Here we see line #11

```
11 cin >> input;
```

The line where we crashed.

Here are some more tutorials for the gdb:

http://www.cs.cmu.edu/~gilpin/tutorial/
https://sourceware.org/gdb/current/onlinedocs/gdb/

(3 pts) Continue working on Assignment 3

Using the skills from this lab, debug a portion of your Assignment 3. If you do not currently have bugs, continue to code Assignment 3 and get help from the TAs.