

Module 9. GDB Debugger

What is “debug”?

1. Find problems (bugs) in a program
2. Remove the bugs (debug) from the program

Objectives

Learn how to debug a program by

1. Adding print statements
2. Using a debugger

Printing Statements

Insert `cout` statements between lines of code

- show values of variables for verification
- see how far the program runs

Shortcoming of Printing Statements

- Too many printing statements make output hard to read (overload output)
- May forget to remove the statements when the program is done
- Not able to follow the program efficiently

Why a Debugger?

- Help developers investigate a program
- Study / trace a program **during** execution
- Useful for catching runtime errors

Key Features of Debugger

- Breakpoint
 - A break in the program execution
 - Execution pauses at the statement with a breakpoint
 - There may be more than one breakpoint in the program
 - After pausing the program, you can follow the execution line by line (step by step)
- Watching variables
 - Track variable values during program execution
 - See what the value of a variable at a specific point in the execution is
 - Watch more than one variable at the same time

GNU Debugger

In this course, we will use the debugger called **GNU debugger** (GDB).

Before Debugging

Programs need to be compiled with debugging information

- Invoke `g++` with option `-g`

Example:

Compile the *hello.cpp* with `-g` flag

```
$ cat hello.cpp
#include<iostream>
struct Node {
    int id;
    Node *next;
};

int main() {
    Node *current = NULL;

    for (int i = 0; i < 5; i++) {
        Node *_newNode = new Node;
        _newNode->id = i;
        _newNode->next = NULL;

        current->next = _newNode;
    }

    return 0;
}

$ g++ -pedantic-errors -std=c++11 -g hello.cpp -o hello
```

Basic GDB commands

- `r` – Start program execution
- `q` – Quit GDB
- `p` – Print the current value of a variable

Example 1:

Console	Action
\$ gdb hello	Launch GDB with <i>hello</i>
(gdb) r Starting program: /home/engg1340/hello Program received signal SIGSEGV, Segmentation fault. 0x00005555555547d2 in main () at hello.cpp:15 15 current->next = _newNode;	Type “r” or “run” to run the program. The running program throws a runtime error at line 15 and pauses at that line.
(gdb) p i \$1 = 0 (gdb) p current \$2 = (Node *) 0x0	Use “p” or “print” command to view the current values of <i>i</i> and <i>current</i> . From the information, we know that when <i>i</i> = 0 in the for loop, current = 0x0 , which is a NULL pointer. Therefore, <i>current</i> -> <i>next</i> is an invalid operation. The bug is found.
(gdb) q	Type “q” to quit GDB

Other useful GDB commands

- `b` – Set breakpoint
- `clear` – Clear breakpoint
- `n` – Execute next line of code
- `l` (small case of `L`) – Display the code

Example 2:

Console	Action
<code>\$ gdb hello</code>	Launch GDB with <i>hello</i>
<code>(gdb) b 8</code> Breakpoint 1 at 0x792: file hello.cpp, line 8.	Type “b 8” or “break 8” to set a breakpoint at line 8
<code>(gdb) r</code> Starting program: /home/engg1340/hello Breakpoint 1, main () at hello.cpp:8 8 Node *current = NULL;	Type “r” or “run” to run the program. The running program stops at the breakpoint (line 8).
<code>(gdb) p i</code> No symbol “i” in current context. <code>(gdb) p current</code> \$1 = (Node *) 0x7fffffffe950	Use “p” or “print” command to view the current values of <code>i</code> and <code>current</code> . The program haven’t seen <code>i</code> at this point. The program just saw <code>current</code> but the statement in line 8 hasn’t been executed yet and so <code>current</code> contains some garbage values.
<code>(gdb) n</code> 10 for (int i = 0; i < 5; i++) { <code>(gdb) p current</code> \$2 = (Node *) 0x0	Use “n” or “next” command to execute the next line of code. current = 0x0 , which is a NULL pointer.
<code>(gdb) n</code> 11 Node *_newNode = new Node; <code>(gdb) n</code> 12 _newNode->id = i; <code>(gdb) n</code> 13 _newNode->next = NULL; <code>(gdb) n</code> 15 current->next = _newNode; <code>(gdb) n</code> Program received signal SIGSEGV, Segmentation fault. 0x00005555555547d2 in main () at hello.cpp:15 15 current->next = _newNode;	Use “n” or “next” command again and again to execute the next few lines of code. The running program throws a runtime error at line 15 and pauses at that line. You can repeat the steps in Example 1 to look for the bug.
<code>(gdb) q</code>	Type “q” to quit GDB

Useful links:

This website introduces more GDB commands:

https://www.tutorialspoint.com/gnu_debugger/gdb_debugging_programs.htm

Example: Another use-case scenario of using GDB to debug a program

https://www.tutorialspoint.com/gnu_debugger/gdb_debugging_example1.htm

Example: Setting breakpoints to help debugging a program

<https://www.geeksforgeeks.org/gdb-step-by-step-introduction/>

Full set of commands:

<http://www.yolinux.com/TUTORIALS/GDB-Commands.html>

Online GDB

This website gives you an online GDB platform to debug a program. Apart from the command line environment, it also includes an interactive panel to show current values of variables and control breakpoints.

<https://www.onlinegdb.com/>