

## Module 10. 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<br>Starting program: /home/engg1340/hello<br><br>Program received signal SIGSEGV, Segmentation fault.<br>0x00005555555547d2 in main () at hello.cpp:15<br>15                   current->next = _newNode; | Type “r” or “run” to run the program.<br><br>The running program throws a runtime error at line 15 and pauses at that line.  |
| (gdb) p i<br>\$1 = 0<br>(gdb) p current<br>\$2 = (Node *) 0x0  | Use “p” or “print” command to view the current values of <i>i</i> and <i>current</i> .<br><br>From the information, we know that when <i>i</i> = 0 in the for loop, <b>current</b> = <b>0x0</b> , 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  |
|--|---|
| <pre>\$ gdb hello</pre>  | Launch GDB with <i>hello</i>  |
| <pre>(gdb) b 8 Breakpoint 1 at 0x792: file hello.cpp, line 8.</pre>  | Type “b 8” or “break 8” to set a breakpoint at line 8   |
| <pre>(gdb) r Starting program: /home/engg1340/hello  Breakpoint 1, main () at hello.cpp:8 8          Node *current = NULL;</pre>   | <p>Type “r” or “run” to run the program.</p> <p>The running program stops at the breakpoint (line 8).</p>   |
| <pre>(gdb) p i No symbol "i" in current context. (gdb) p current \$1 = (Node *) 0x7fffffffe950</pre>   | <p>Use “p” or “print” command to view the current values of <code>i</code> and <code>current</code>.</p> <p>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.</p> |
| <pre>(gdb) n 10          for (int i = 0; i &lt; 5; i++) { (gdb) p current \$2 = (Node *) 0x0</pre>   | <p>Use “n” or “next” command to execute the next line of code.</p> <p><b>current = 0x0</b>, which is a NULL pointer.</p>  |
| <pre>(gdb) n 11          Node *_newNode = new Node; (gdb) n 12          _newNode-&gt;id = i; (gdb) n 13          _newNode-&gt;next = NULL; (gdb) n 15          current-&gt;next = _newNode; (gdb) n  Program received signal SIGSEGV, Segmentation fault. 0x00005555555547d2 in main () at hello.cpp:15 15          current-&gt;next = _newNode;</pre> | <p>Use “n” or “next” command again and again to execute the next few lines of code.</p> <p>The running program throws a runtime error at line 15 and pauses at that line.</p> <p>You can repeat the steps in Example 1 to look for the bug.</p>   |
| <pre>(gdb) q</pre>   | Type “q” to quit GDB  |

## Useful links:

This website introduces more GDB commands:

[https://www.tutorialspoint.com/gnu\\_debugger/gdb\\_debugging\\_programs.htm](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](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/>