

## CSE 333 22au – Section 2: Structs and Debugging

In this class, it is very helpful to be comfortable with `gdb` and `valgrind` as debugging tools. `gdb` allows you to see the source code and has many useful commands for analyzing your program; `valgrind` catches many types of runtime memory errors.

Plenty of debugging resources can be found on the CSE333 Resources Page: <https://courses.cs.washington.edu/courses/cse333/22au/resources.html>

### Starting `gdb`

*For `gdb` to work with your C/C++ program, you must compile it using the “-g” flag!*  
To start up `gdb`, run the following command (the `-tui` flag is optional and enables a text UI).

```
bash$ gdb -tui <program file name>
```

### Some essential `gdb` commands

If you want to know more, ask a TA or investigate the resources at the top of the page.

#### Setting Breakpoints and Continuing

- `break <filename>:<line #>` Set a new breakpoint
- `info breakpoints` Prints information about the set breakpoints
- `continue` Continue normal execution

#### Controlling Program Execution

- `run <command_line_args>` Run the program with provided `command_line_args`
- `next` Go to next instruction, but don't dive into functions
- `step` Go to next instruction, and dive into functions
- `finish` Continue until current function returns
- `quit` close `gdb`

#### Examining the Current Program

- `list` Shows the current or given source context
- `backtrace` Shows the call stack
- `up` Moves up a stack frame
- `down` Moves down a stack frame
- `frame <#>` Move to a specific stack frame
- `print <expression>` Prints content of variable/memory location/register

### Starting `valgrind`

Note that `valgrind` only analyzes the code reached during a specific execution of your program. Run the following command:

```
bash$ valgrind --leak-check=full ./<program file name>
```

## reverse.c

Download full code on the course website.

```
/* Ask user for a word and print it forwards and backwards.
 * CSE 333 demo (for debugging), HP
 */

#define MAX_STR 100 /* length of longest input string */

#include <stdio.h>
#include <stdlib.h>
#include <string.h>

/* Return a new string with the contents of s backwards */
char * reverse(char * s) {
    char * result = NULL; /* the reversed string */
    int L, R;
    char ch;

    /* copy original string then reverse and return the copy */
    strcpy(result, s);

    L = 0;
    R = strlen(result);
    while (L < R) {
        ch = result[L];
        result[L] = result[R];
        result[R] = ch;
        L++; R--;
    }

    return result;
}

/* Ask the user for a string, then print it forwards and backwards.
 */
int main() {
    char line[MAX_STR]; /* original input line */
    char * rev_line; /* backwards copy from reverse function */

    printf("Please enter a string: ");
    fgets(line, MAX_STR, stdin);
    rev_line = reverse(line);
    printf("The original string was:  >%s<\n", line);
    printf("Backwards, that string is: >%s<\n", rev_line);
    printf("Thank you for trying our program.\n");
    return EXIT_SUCCESS;
}
```

## Exercise 1

Draw a memory diagram for the execution of the code above up to the call to `strcpy()` in `reverse()`. Make sure to distinguish between local variables on the Stack and Heap-allocated memory.

## Exercise 2

Feel free to make a few code changes based on your findings in Exercise 1. However, the rest of your time for this exercise should be spent in `gdb` and `valgrind` and NOT staring at the code. Find and fix all of the remaining logical and memory errors in the code and try to document/associate each fix with the tool features or output that led you there.

Please use the space below for documenting your errors fixed and tooling assistance.

## Exercise 3

Fix any remaining style issues with the code in `reverse.c`.

## simplestring.c

```
/* Buggy code for CSE 333 Section 2
 * 1. Draw a memory diagram for the execution to identify errors.
 * 2. Use gdb and valgrind to identify sources of runtime, logical,
 * and memory errors.
 * 3. Clean up the code style.
 */
#include <string.h> // strncpy, strlen
#include <stdio.h> // printf
#include <stdlib.h> // malloc, EXIT_SUCCESS, NULL

// A SimpleString stores a C-string and its current length
typedef struct simplestring_st {
    char* word;
    int length;
} SimpleString;

// Allocate a new SimpleString on the heap initialized with word
// and return pointer to the new SimpleString in dest
void InitWord(char* word, SimpleString* dest);

int main(int argc, char* argv[]) {
    char comp[] = "computer";
    SimpleString ss = {comp, strlen(comp)};
    SimpleString* ss_ptr = &ss;

    // expecting "1. computer, 8"
    printf("1. %s, %d\n", ss_ptr->word, ss_ptr->length);

    char cse[] = "cse333";
    InitWord(cse, ss_ptr);
    // expecting "2. cse333, 6"
    printf("2. %s, %d\n", ss_ptr->word, ss_ptr->length);

    return EXIT_SUCCESS;
}

void InitWord(char* word, SimpleString* dest) {
    dest = (SimpleString*) malloc(sizeof(SimpleString));
    dest->length = strlen(word);
    dest->word = (char*) malloc(sizeof(char) * (dest->length + 1));
    strncpy(dest->word, word, dest->length + 1);
}
```

## Exercise 4 (Bonus)

Draw a memory diagram of the execution of the above code (`simplestring.c`). Be sure to differentiate between memory on the Stack and Heap-allocated memory.

## Exercise 5 (Bonus)

Can you identify and fix the bug causing issues with the initialization of our `SimpleString` structs?