Integer Pointers Program

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CSC450-1 23WD: Programming III

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Integer Pointer Application

For this assignment, the students were asked to create a console application in C/C++ that gets three integers from a user, creates pointers to the memory locations for those pointers, prints the stored integers and memory pointers to the console, then releases the memory the pointers point to for reallocation.

Vetting and Cleaning the Input

As I was thinking of how to force user input to a valid integer, I thought about making sure a human entered a valid integer, and considered what input from an improperly cleaned data source might look like. Examples for machine input for the integer 2112 might be <2112>, [(2112)], "2112,", 2112.0, 2112, etc. So, I wrote a Regular Expression (regex) pattern to mask the input. I get the input as a string using `getline(cin, string)`, then filter it through the following regex mask:

```
regex_replace(input, regex(R"([^\-0-9.]+)"), "")
```

This takes all non-numeric values except for hyphen – (for negative integers) and removes them from the string by replacing them with an empty string. It also will stop at a decimal point, so the value 2112.0 becomes 2112 and then omits the decimal point. It can make invalid data seem correct and then process it, for example 1,2,3, from a csv input (which should throw an exception in a production model) would be interpreted as 123 instead. But it is a good start for a model that will accept improperly sanitized input. It will also strip whitespace which can often occur when a human copies and pastes data from a table. Source Code 1 shows the `get_integer()` function, which can also be ported easily to another program, or even modified and added to a header file, something like int `xstoi(string input)` which could take an

invalid input string and return a valid integer, and would throw an exception if the input were unparsable as an int. The full source code for the entire program is in Appendix A

Source Code 1

Source code for the get_integer function.

```
int get_integer() {
    int integer;
    string input;
    bool valid;
    cout << "Enter an integer value: ";
    do {
        getline(cin, input);
        try {
            integer = stoi(regex_replace
                    (input, regex(R"([^\-0-9.]+)"), ""));
            valid = true;
        } catch (invalid_argument const &ia) {
            valid = false;
            cout << "Input cannot be parsed. "
                    "Enter a valid integer value: ";
            cin.clear();
        } catch (out_of_range const &oor){
            valid = false;
            cout << "Input is out of range for this machine. "
                    "Enter a valid integer value: ";
            cin.clear();
        }
    } while (!valid);
    return integer;
}
```

Displaying the References – First Attempt

My first attempt at displaying the references was a failure, I wasn't really thinking about what a memory location for a variable actually is, so I used an array and a foreach loop so the code would be cleaner. But by doing this, I was creating a new variable in the loop which was purged and re-created at each iteration, so the returned references did not refer to the location of the actual integers, but to the variable in the foreach loop instead. When the program printed the references to the console, naturally all the reference values were identical (as would be

expected). Source code 2 shows the function I wrote that gives reference information for the variable within the foreach loop rather than pointers to the variables themselves:

Source Code 2

Source code for my failed initial attempt to show the reference information.

```
void integer_reference_loop() {
    int counter = 0,
        integer_1 = get_integer(),
        integer_2 = get_integer(),
        integer_3 = get_integer();
    const int INTEGER_ARRAY[3] = {integer_1, integer_2, integer_3};
    for (int integer: INTEGER_ARRAY) {
        counter++;
        printf("Integer %d: %-11d, Reference %d: %p\n",
               counter, integer, counter, &integer);
    }
}
```

Displaying the References – Second Attempt

My second attempt at creating and printing the references was successful, but it does not meet the purpose of the exercise --to show creation of pointer (`int *`, `void *`, `etc.`) data types and removal of the pointers to free memory. This function only displayed references, and references cannot be freed, cleared, or deleted, I abandoned it and re-write the function.

Source Code 3

Source code for my second attempt function.

```
void show_references() {
    int integer_1 = get_integer(),
        integer_2 = get_integer(),
        integer_3 = get_integer();
    printf("Integer 1: %-11d Integer 1 Reference: %p\n"
           "Integer 2: %-11d Integer 2 Reference: %p\n"
           "Integer 3: %-11d Integer 3 Reference: %p\n",
           integer_1, &integer_1,
           integer_2, &integer_2,
           integer_3, &integer_3);
}
```

Creating the Pointers – Final Function

The final version of the function creates three separate integer variables and creates a pointer for each variable. I chose to use `malloc()` to create the pointers, so I could use `free()` to release them. There are three common ways to create pointers and free the memory associated with them:

1. ```
   int *pointer = new int(value);
   delete pointer;
   ```
2. ```
   int j = value;
   void *pointer = malloc(sizeof(j));
   free(pointer);
   ```
3. ```
   int j = value;
   int *pointer = &j;
   pointer = nullptr;
   ```

(LePage 2017).

This will not remove the values inside the volatile memory, they will merely release the pointer. If the values are truly sensitive, the more destructive method `memset(pointer, 0, sizeof(*pointer))`should be used. I merely used `free()`for this exercise. Using delete is undesirable, as this leads to undefined behavior (Stieber, et. al. 2017). The preferred method is to have the values as local variables in a function or method and allow them to be freed at termination of the function or method (Reid, 2012). I chose to do this as well. Source code 4 shows the function as submitted for compilation.
   ```

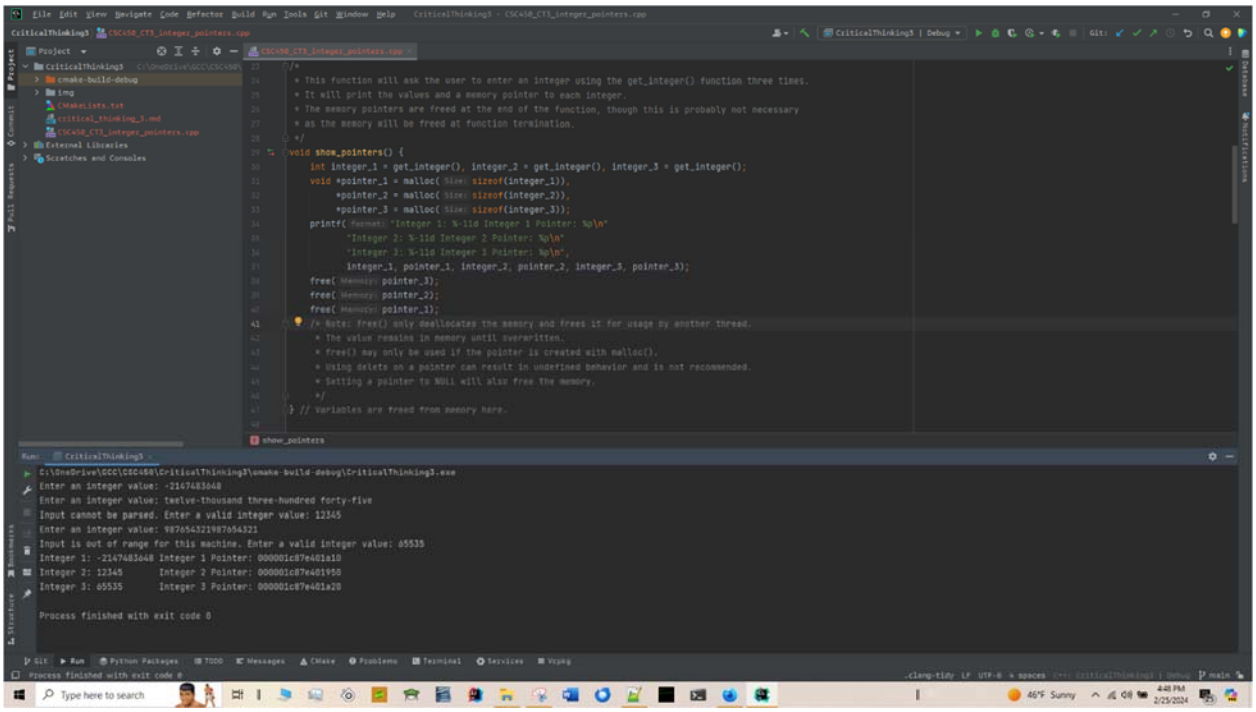
Source Code 4

Final show_pointers() function as submitted for compilation.

```
void show_pointers() {
    int integer_1 = get_integer(), integer_2 = get_integer(), integer_3 =
get_integer();
    int  *pointer_1 = new int(integer_1);
    void *pointer_2 = malloc(sizeof(integer_2));
    int  *pointer_3 = &integer_3;
    printf("Integer 1: %-11d Integer 1 Pointer: %p\n"
           "Integer 2: %-11d Integer 2 Pointer: %p\n"
           "Integer 3: %-11d Integer 3 Pointer: %p\n",
           integer_1, pointer_1, integer_2, pointer_2, integer_3,
pointer_3);
    delete pointer_1;
    free(pointer_2);
    pointer_3 = nullptr;
}
```

Figure 1

Running the CSC450_CT3_integer_pointers.cpp program



Vulnerability Assessment

The `free()` command does not wipe the value from volatile memory. If the information is sensitive, `memset(pointer, 0, sizeof(*pointer))` should be used to completely wipe the values from memory. These commands will require more processing time to use, negligible in this program but if this is standard practice for non-sensitive information it will unnecessarily task resources in larger enterprise-type applications. This console app initially uses a string for input, so in an unusual case a malicious user *could* enter a string so large it would consume the entire memory allocated to the execution of the program, in essence forcing a Denial of Service (DoS) for concurrent users of the software or machine, an assessment of this would need to take place before deployment. This program also uses printf, which if incorrectly coded may introduce the Format String Vulnerability (CWE 134) (Du, 2014). The printf function as written in this code is compliant with current security standards.

GitHub Repository

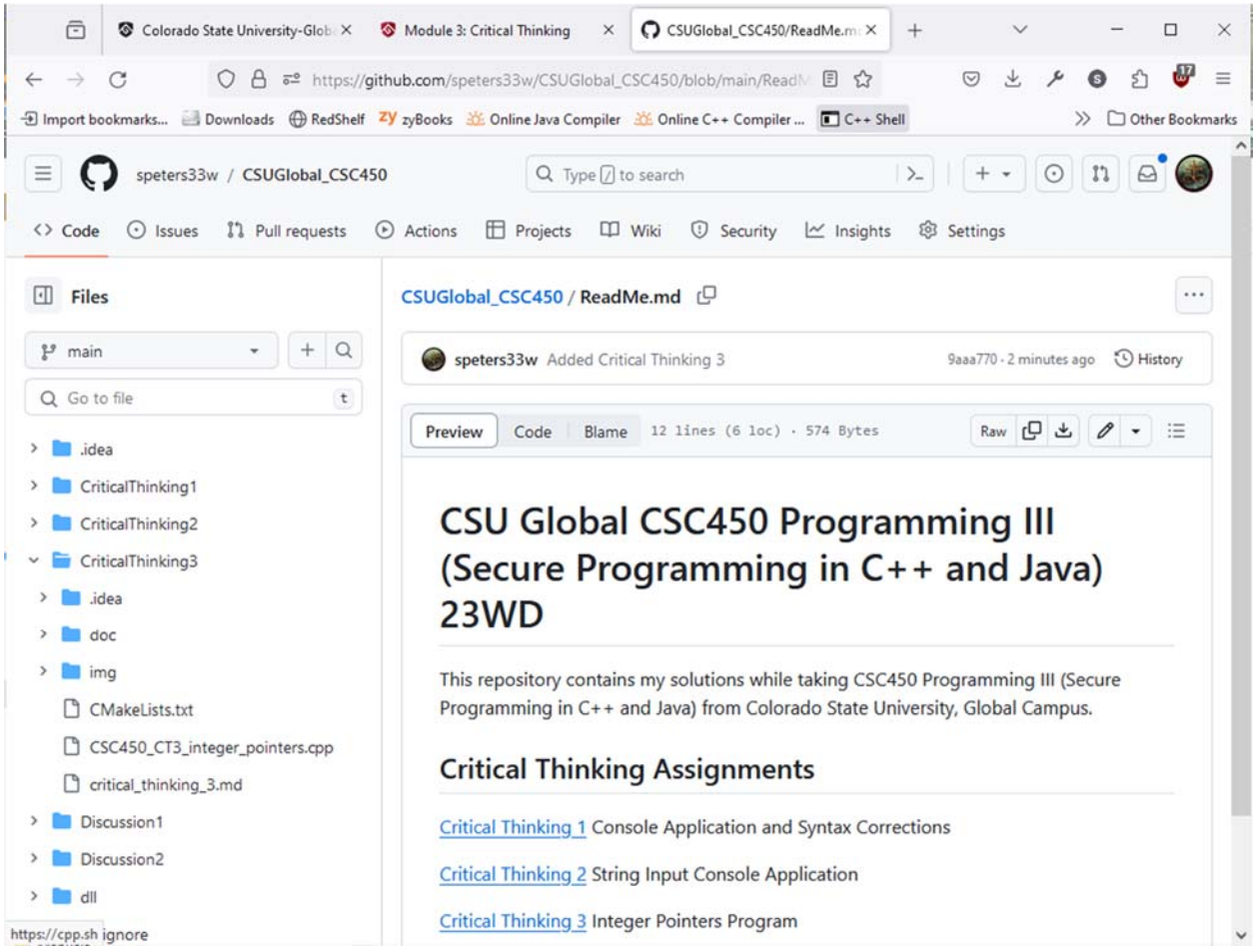
In addition to the solutions above, I was tasked to create a GitHub repository for the project. This repository is located at

https://github.com/speters33w/CSUGlobal_CSC450/tree/main/CriticalThinking3

Figure 2 shows a screenshot of the main page of this repository.

Figure 2

Image of the main page of my CSC 450 GitHub repository



Appendix A – Full Source Code as Submitted

Source Code 5

Final source code as submitted for compilation.

```
/*
 * A simple C/C++ program that takes three integers from a user,
 * creates memory pointers for those integers,
 * then prints the integers and pointer references to the screen.
 * (CSC450_CT3_integer_pointers.cpp)
 */

#include <iostream>
#include <regex>
#include <string>

void show_pointers();

int get_integer();

using namespace std;

int main() {
    show_pointers();
    return 0;
}

/*
 * This function will ask the user to enter an integer using the
get_integer() function three times.
 * It will print the values and a memory pointer to each integer.
 * The memory pointers are freed at the end of the function, though this is
probably not necessary
 * as the memory will be freed at function termination.
 */
void show_pointers() {
    int integer_1 = get_integer(), integer_2 = get_integer(), integer_3 =
get_integer();
    int  *pointer_1 = new int(integer_1);
    void *pointer_2 = malloc(sizeof(integer_2));
    int  *pointer_3 = &integer_3;
    printf("Integer 1: %-11d Integer 1 Pointer: %p\n"
           "Integer 2: %-11d Integer 2 Pointer: %p\n"
           "Integer 3: %-11d Integer 3 Pointer: %p\n",
           integer_1, pointer_1, integer_2, pointer_2, integer_3,
pointer_3);
    delete pointer_1;
    free(pointer_2);
    pointer_3 = nullptr;
    /* Note: these methods only deallocate the memory and frees the pointer.
     * The value remains in memory until overwritten.
     * To wipe the memory, use  memset(pointer, 0, sizeof(*pointer)).
     */
} // Variables are freed from memory here.
```

```
/*
 * This function autocorrects typos or improperly sanitized input from a
data source
 * and ensures input may be interpreted as an integer.
 * <2112>, [(2112)], "2112,", 2112.0, <span style = "numeral">2112</span>
 * will all be interpreted as 2112.
 * 12ThreeFour56 will be interpreted as 1256
 * 67.89 will be interpreted as 67
 * 98-76 will be interpreted as 98
 * It will ask the user to re-enter data if there are no digit values.
 * It will ask the user to re-enter if the integer is out of range.
 * Valid integer data, e.g. -1234 or 9876 is returned as entered.
 */
int get_integer() {
    int integer;
    string input;
    bool valid;
    cout << "Enter an integer value: ";
    do {
        getline(cin, input);
        try {
            integer = stoi(regex_replace(input, regex(R"([^\-0-9.]+)"),
""));
            valid = true;
        } catch (invalid_argument const &ia) {
            valid = false;
            cout << "Input cannot be parsed. Enter a valid integer value: ";
            cin.clear();
        } catch (out_of_range const &oor){
            valid = false;
            cout << "Input is out of range for this machine. Enter a valid
integer value: ";
            cin.clear();
        }
    } while (!valid);
    return integer;
} // Variables other than the return value are freed from memory here.

/*
 * This function will ask the user to enter an integer using the
get_integer() function three times.
 * It will print the values and a memory reference to each integer.
 * The references are not stored in a pointer and are freed at the function
termination.
 * If pointers were created and values stored and returned,
 * delete or free() could be used to dereference the storage in memory
 * depending on the way the pointer was created.
 */
[[maybe_unused]] void show_references() {
    int integer_1 = get_integer(), integer_2 = get_integer(), integer_3 =
get_integer();
    printf("Integer 1: %-11d Integer 1 Reference: %p\n"
           "Integer 2: %-11d Integer 2 Reference: %p\n"
           "Integer 3: %-11d Integer 3 Reference: %p\n",
           integer_1, &integer_1, integer_2, &integer_2, integer_3,
&integer_3);
```

```
} // Variables are freed from memory here.

/*
 * The loop in this function did not satisfy the purpose of the assignment,
 * as the reference will always be to the local integer variable within the
for each loop.
 * It will print the same reference address to the screen three times
because at each iteration
 * the local integer variable is destroyed and overwritten.
 * It does not provide the reference address for integer_1, integer_2, or
integer_3.
 * It is unused and left here for demonstration.
 */
[[maybe_unused]] void integer_reference_loop() {
    int counter = 0, integer_1 = get_integer(), integer_2 = get_integer(),
integer_3 = get_integer();
    const int INTEGER_ARRAY[3] = {integer_1, integer_2, integer_3};
    for (int integer: INTEGER_ARRAY) {
        counter++;
        printf("Integer %d: %-11d Reference %d: %p\n", counter, integer,
counter, &integer);
    }
} // Variables are freed from memory here.
```

References

Du, W. (Kevin). (2014). Format String Vulnerability printf (user input). In *Department of Electrical Engineering and Computer Science, Syracuse University*. https://web.ecs.syr.edu/~wedu/Teaching/cis643/LectureNotes_New/Format_String.pdf

LePage, G. (2017, November 3). *How do I clear an int pointer (int *pointer) from memory on C++?* Quora. https://www.quora.com/How-do-I-clear-an-int-pointer-int-*pointer-from-memory-on-C++

Reid (ModShop), B. (2012, October 18). *How to delete a variable. - C++ Forum*. Cplusplus.com. https://cplusplus.com/forum/beginner/82290/

Stieber et. al., C. (2017, May 23). *What does delete command really do for memory, for pointers in C++?* Stack Overflow. https://stackoverflow.com/questions/11603005/what-does-delete-command-really-do-for-memory-for-pointers-in-c