CS214 Assignment 1

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Abstract

This document is project assignment 1: ++Malloc for Systems Programming (01:198:214) at Rutgers University - Fall 2020.

1 Setup your Environment

Within Asst0.tgz file, we have four files that are utilized to run ++Malloc.

mymalloc.c: This is the file that has our methods of *mymalloc()* and *myfree()* to demonstrate the purpose of this assignment.

mymalloc.h: This is a header file which allows us to link methods between files.

memgrind.c: This is the primary testing environment for our program. Within this file, we have five different tests and our output to demonstrate the overall efficiency of our program.

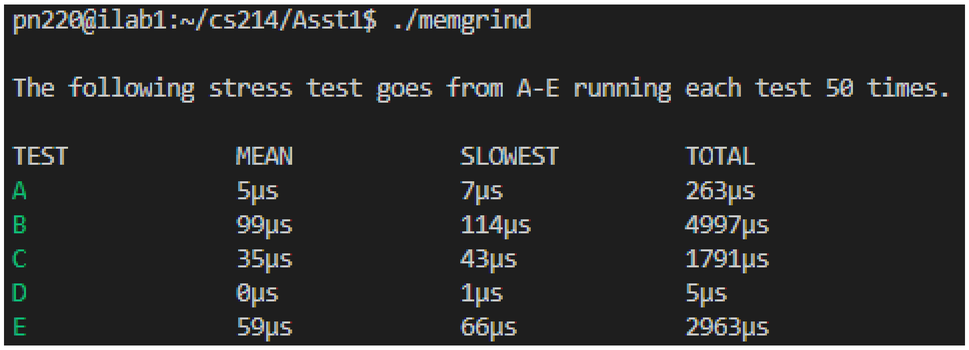
Makefile: This file allows us to compile and remove the program.

To begin: place mymalloc.c, mymalloc.h, memgrind.c, and Makefile all into the same directory on the iLab machine. Within terminal, type "*make*" which will generate an executable called 'memgrind'.

To clean the document, you can type `'make clean'` in the terminal, and this will remove the executable memgrind, and any associating files that are related to running memgrind.

2 Running ++Malloc

To run this program, we can type "*./memgrind*" into terminal after we have used the make command in the previous section. Arguments are not required to run this program, however, you may utilize "> *output.txt*" to store the output into a file called output.txt which would be in the same directory as the program rather than looking at the output in terminal.



```
pn220@ilab1:~/cs214/Asst1$ ./memgrind

The following stress test goes from A-E running each test 50 times.

TEST            MEAN            SLOWEST         TOTAL
A               5µs             7µs             263µs
B               99µs            114µs           4997µs
C               35µs            43µs            1791µs
D               0µs             1µs             5µs
E               59µs            66µs            2963µs
```

Once ran, we can expect some output generated that will demonstrate the overall effectiveness of the program. Below is a description of each test labeled from A to E to denote what we were testing with the program.

Test A: For 120 iterations, we had to malloc() 1 byte, and immediately free it.

Test B: For 120 iterations, fill up an array where each index of the array is a single byte that has been malloc(). Once the array has been filled, iterate through the array, and free each 1 byte pointer.

Test C: For 240 iterations, randomly choose between malloc() or free() a single byte; however, there are restrictions. Our first restriction: you cannot free() a byte that has not been malloc'd. Our second restriction: once 120 bytes have been malloc'd, immediately free the remainder of the bytes.

Test D: This workload is meant to test failure cases that would traditionally cause conflicts with malloc/free. We utilized test cases provided from Asst1.pdf to denote the following issues that may arise with user input.

Test E: In workload E, we are looking to test the efficiency of our merging, as it is important for malloc to handle merging of blocks that are not utilized. Please view *testcases.txt* for a more elaborate explanation of workload E.

Each workload will be completed 50 times, and total time will be accumulated and divided by total workload to obtain average time for workload to complete. The output display will show the average, slowest, and total run time for each workload from A to E. The units that these tests are measured in are μs.

3 Design Implementation

In this section, we will discuss the design implementation in regarding metadata design and any other features that we deemed needed more explanation.

Metadata Design: In choosing an efficient method to keep track of how much data each pointer allocated in our fixed array is associated with, the design decision was made to use a 2-byte metadata that could be created in the form of `int16_t`, which is a 16-bit signed integer available in the `stdint.h` header file. In our 4096-byte virtual memory, we will have this 2-byte integer before every block of memory, and the metadata will simply represent a the amount of space available in the space ahead of it, with the first 2 bytes of our virtual memory always being a metadata value. With this design, when we need to find all pointers, we can simply extract the integer value at the first 2-bytes of our 4096-byte virtual memory, and traverse our way down to the next metadata in a linked list fashion. Even more so, we also need to be able to represent when a block of memory is available or not, and this can cleverly be represented in our metadata without the use of pointer arithmetic. For an available block, the metadata is a positive integer representing the size. For an unavailable block, the metadata is just the negative, with the absolute value representing the size of the block.

2	**40**	**2**	**70**	**2**	**100**
40	Data	70	Data	-100	Free

Figure 1: Sample memory layout

Memory Defragmentation: When our free function is used, it will simply subtract 2 bytes from the given pointer, cast the pointer to type `int16_t*`, and then dereference the pointer to obtain the block size. Free will perform this, then flip the integer to a negative, and store it back at the location with the `memcpy()` function. The problem arises when we have adjacent blocks that are free. In this case, they need to be merged, or over the usage of the virtual memory, we will converge to smaller and smaller regions.This is fixed with our `merge()` function, which is called in the `myfree()` function. Merge simply checks for all adjacent free blocks, and will replace the first metadata of these blocks with the total size of the adjacent bytes that are free. This ensures that maximum space can be used by calls to `mymalloc()`.