IT 308-Operating System

OS Mini Project

Project name : Mymalloc
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Abstract:

The purpose of this project is to create an improved version of malloc and free using macros in our mymalloc.h file.

#define malloc(x) mymalloc(x, __FILE__, __LINE__)
#define free(x) myfree(x, __FILE__, __LINE__)

The extra parameters are used to indicate the file name and line number where an error occurred.However, unlike the conventional malloc and free, this version will treat errors nicely by not returning a vague Segmentation Fault and printing the reason as well as the location of the cause of a failed malloc/free.

Malloc(size_t size) will return a pointer to a block of memory whose size is at least the requested size. These blocks of memory will come from a 5000-byte char array defined in mymalloc.c,

static char myblock[5000];

In this case, HEAP_SIZE is 5000. Free(void *) will allow the user to tell the system that he/she is done with a dynamically allocated block of memory hence system will remove that block.

II. Common errors with malloc and free

When freeing an address to memory that was not dynamically allocated, the usual result is exiting the program. With our free, the user will instead be told that the address inputted was not on the heap. In this case, the heap is the 5000-byte char array that simulates virtual memory.

```
if(ptr == NULL){
printf("Error in %s, line %d: Null pointer.\n", file_name, line_number);
                return;
        }

        Metadata* meta_ptr = (Metadata*)(ptr - sizeof(Metadata));

if(meta_ptr < first_metadata || (char *)ptr > &myblock[max_size-1]){
printf("Error in %s, line %d: Invalid pointer.\n", file_name, line_number);
                return;
        }
```

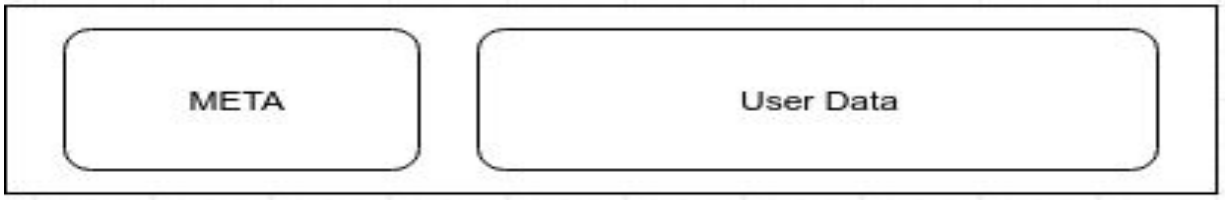
In above function it determines block whether exist or not, after looking through every meta block within virtual memory, the address entered pointed to the first byte of a user data block. If the block was not found, then the address is not a valid address in the heap. Therefore, the user will be told this instead of exiting the program.

When asking for more data than can be requested, the usual result is once again exiting the program with no explanation. With our malloc, it'll tell you the reason why the operation cannot be executed. For example, if you tried *malloc(5001)*, you will be told that there isn't enough space in virtual memory to allocate 5001 bytes. This is reasonable since our emulated memory is only 5000 bytes. Taking into account the size of the meta block (8 bytes), the max amount of memory that can be dynamically allocated is 4992 bytes. For other common errors in malloc and free, check the comments by the print statements in mymalloc.c

III. How malloc works

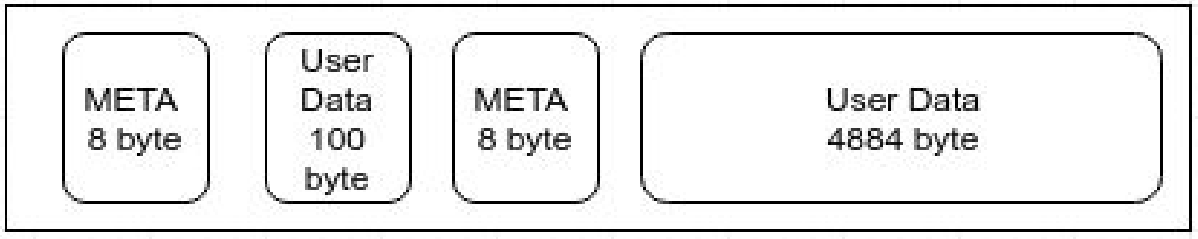
The first malloc call will call our bootstrap method which essentially "sets up" virtual memory for us. Setting up virtual memory is basically

initializing virtual memory with one meta block that covers all the memory left in the char array. Since a meta block is 8 bytes, the user data it encompasses is 4992 bytes as a result.



When allocating memory, malloc will search through every meta block and find the smallest one that can hold the requested amount of memory. For the first malloc of course, the first and only meta block will be the source of the address returned.

Assuming the user called malloc(100), 4992 bytes is too much memory to supply the user. In fact, if the address, meta_block + sizeof(meta), was returned, then over 4000 bytes would go to waste. So what happens is that the user data block you see above would be split and the result would be two meta blocks that correspond to two different user data blocks,



Assuming the first meta block corresponds to the user data to the immediate right of 100 bytes and the second meta block corresponds to the user data to the immediate right of the leftover 4992 – 100 – 8 = 4884 bytes, the address returned from a malloc(100) call would be the address of the first meta block + sizeof(meta).

IV. How free works:

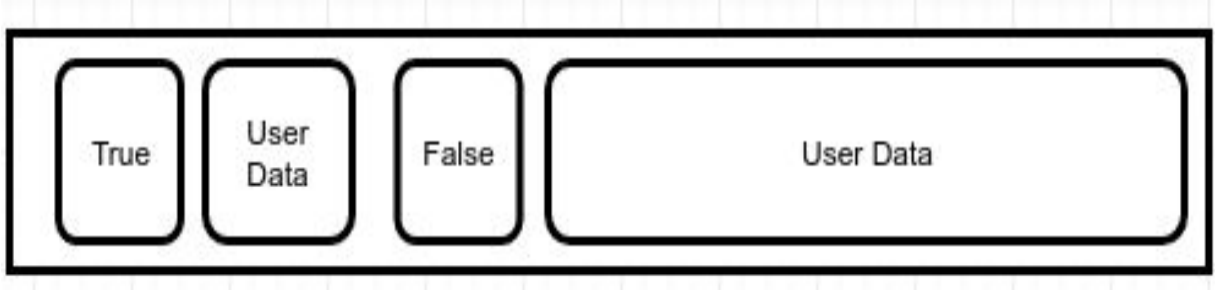
Calls to free will look at the inputted address and try to determine whether it is a valid address within main memory. Valid as in if it points to the first byte of a user data block that is in use, meaning it has not been freed already. Each meta block consists of a size variable and an allocated variable.

If the address inputted is valid, then the allocated variable of its corresponding meta block will be set to false.

Suppose the address of the second user data block was entered into free where virtual memory consisted of three meta blocks and three user data blocks with the first two meta blocks whose allocatation is true while the last meta block's allocation is false before the call to free the second block. Here would be the resulting main memory,

Before free second block,

After free second block,

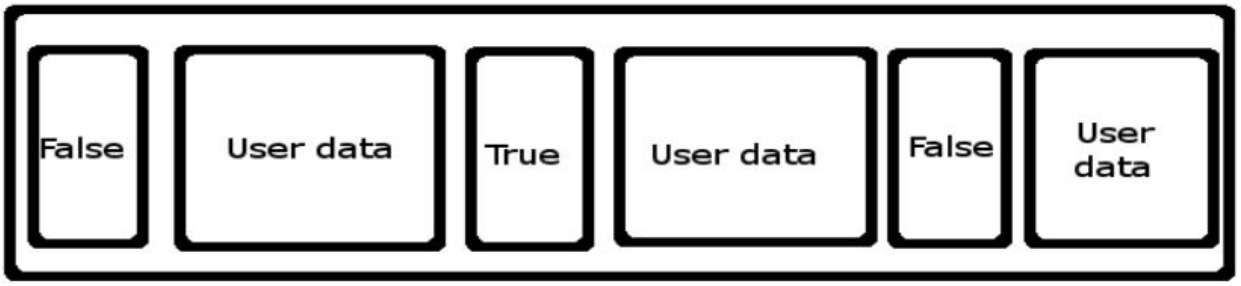


Now, Imagine if the address of the first user data block was entered into free where virtual memory consisted of three meta blocks and three user data blocks with the first two meta blocks whose allocatation is true while

the last meta block's allocation is false before the call to free the first block. Here would be the resulting main memory,

Before Free First block:

After Free First block



Now imagine if the second data block was requested to be freed, the interesting result would be a coalescing algorithm used in our free, which would be to look for nearby meta blocks to determine whether we could combine blocks that were not in use. So the resulting main memory from freeing the middle two blocks would be one meta block and its user data block that encompassed all of main memory.