Report (ECE 650 Project 2)

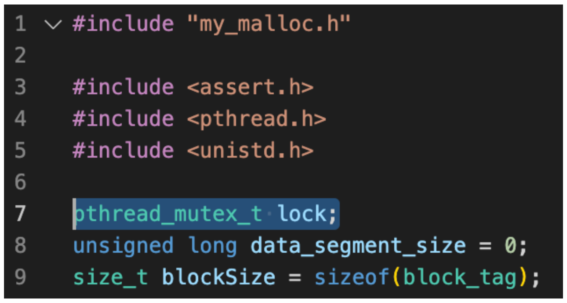
Name: Yichen Huang

NetID: yh348

Date: 02/09/2023

Overview: Description of thread-safe model

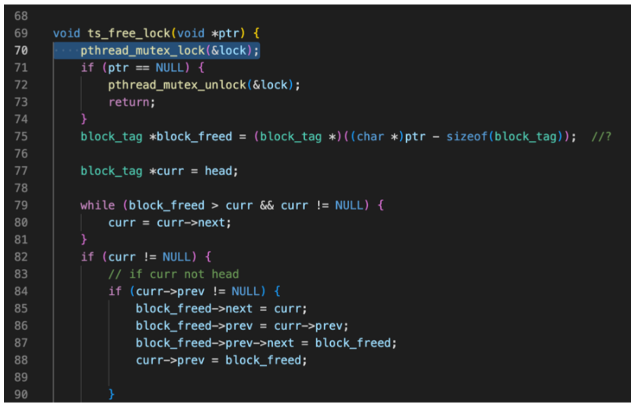
The implementation includes two versions: lock and no lock. First of all, a lock should be initialized with the line of code highlighted in figure 1.



```c
#include "my_malloc.h"

#include <assert.h>
#include <pthread.h>
#include <unistd.h>

pthread_mutex_t lock;
unsigned long data_segment_size = 0;
size_t blockSize = sizeof(block_tag);
```

Figure 1. Code of initialization for a lock

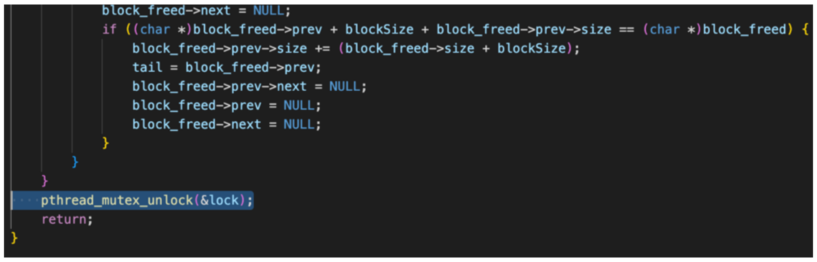
For lock version, the code of best fit in the first project is used. The implementation way is to add the highlighted line of code in figure 2-1 at the beginning of both malloc and free.



```c

void ts_free_lock(void *ptr) {
    pthread_mutex_lock(&lock);
    if (ptr == NULL) {
        pthread_mutex_unlock(&lock);
        return;
    }
    block_tag *block_freed = (block_tag *)((char *)ptr - sizeof(block_tag));  //?

    block_tag *curr = head;

    while (block_freed > curr && curr != NULL) {
        curr = curr->next;
    }
    if (curr != NULL) {
        // if curr not head
        if (curr->prev != NULL) {
            block_freed->next = curr;
            block_freed->prev = curr->prev;
            block_freed->prev->next = block_freed;
            curr->prev = block_freed;

        }
```

Figure 2-1. Code for lock version (at the beginning)

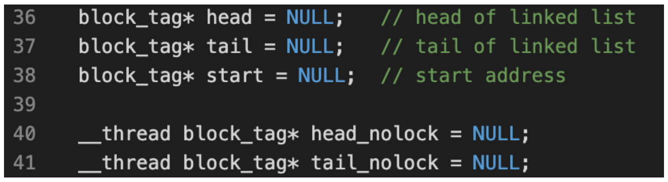
Then add the highlighted line of code in figure 2-2 before each “return” in malloc and free.



```c
                block_freed->next = NULL;
                if ((char *)block_freed->prev + blockSize + block_freed->prev->size == (char *)block_freed) {
                    block_freed->prev->size += (block_freed->size + blockSize);
                    tail = block_freed->prev;
                    block_freed->prev->next = NULL;
                    block_freed->prev = NULL;
                    block_freed->next = NULL;
                }
            }
        }
    pthread_mutex_unlock(&lock);
    return;
}
```

Figure 2-2. Code for lock version (at the end)

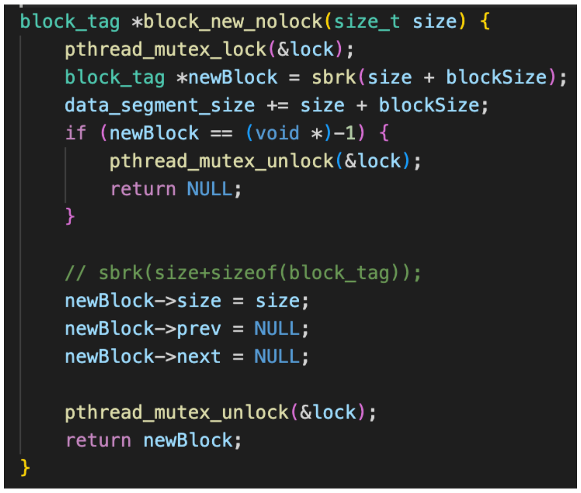
For no lock version, the original code of best fit in the project 1 is also used. The way to implement is to modify the type of head and tail from "block_tag*" to "__thread block_tag*", and use head and tail in new type in the implementation. Figure 3 demonstrates the type modification for both head and tail.



```c
block_tag* head = NULL;   // head of linked list
block_tag* tail = NULL;   // tail of linked list
block_tag* start = NULL;  // start address

__thread block_tag* head_nolock = NULL;
__thread block_tag* tail_nolock = NULL;
```

Figure 3. Head and tail in new version

The other modification is to add lock and unlock just like for lock version for the function where sbrk() is called.



```c
block_tag *block_new_nolock(size_t size) {
    pthread_mutex_lock(&lock);
    block_tag *newBlock = sbrk(size + blockSize);
    data_segment_size += size + blockSize;
    if (newBlock == (void *)-1) {
        pthread_mutex_unlock(&lock);
        return NULL;
    }

    // sbrk(size+sizeof(block_tag));
    newBlock->size = size;
    newBlock->prev = NULL;
    newBlock->next = NULL;

    pthread_mutex_unlock(&lock);
    return newBlock;
}
```

Figure 4. Modification related to sbrk() function for no lock version

Performance Result Presentation

With locking and no-locking version of thread-safe malloc/free functions, different results related to

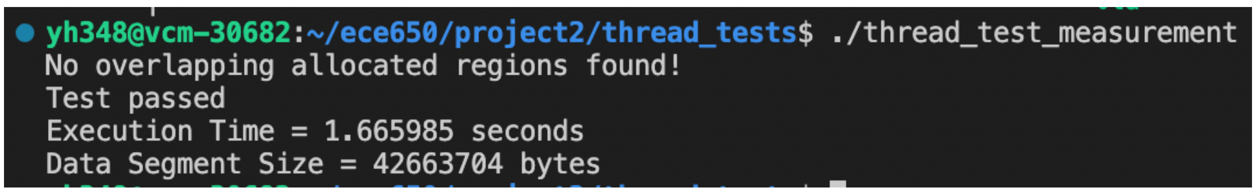
- Execution time: the run-time of the program
- Allocation efficiency: the total size of the data segment after running the test

are shown in Table 1.

Table 1. Results of First Fit and Best Fit

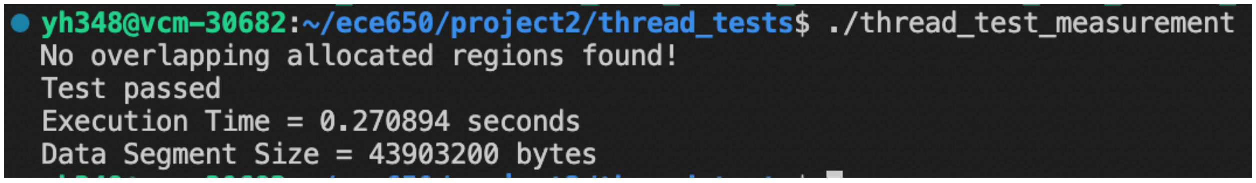
	Lock	No Lock
Execution Time (s)	1.665985	0.270894
Data Segment Size (bytes)	42663704	43903200

The data printed in terminal has been shown in figure 5 and figure 6.



```
yh348@vcm-30682:~/ece650/project2/thread_tests$ ./thread_test_measurement
No overlapping allocated regions found!
Test passed
Execution Time = 1.665985 seconds
Data Segment Size = 42663704 bytes
```

Figure 5. Results of locking version



```
yh348@vcm-30682:~/ece650/project2/thread_tests$ ./thread_test_measurement
No overlapping allocated regions found!
Test passed
Execution Time = 0.270894 seconds
Data Segment Size = 43903200 bytes
```

Figure 6. Results of no locking version

Results Analysis

About execution time, time for locking version is approximately 6 times longer than time for no locking version. The reason is that, for lock version, only one single free list is shared by all threads because of locking; but for no lock version, several threads can operate simultaneously.

About data segment size, there is no significant difference between locking and no locking version. Although single free list used for lock version and multiple free list used for no lock version, the block hit rate seems have no evident difference. If on single free list a block cannot hit, on a multiple free lost it also cannot hit. However, based on analysis, memory reuse rate for no locking version will be worse than for locking version, since separate free list for different threads may have adjacent free blocks which cannot be merged together. Thus, the data segment size of locking version is slightly smaller than no locking version.

Thus, the trade-off here is that, in the case of execution time is more important, no locking version is evidently better; when memory size is regarded as the more significant factor, locking version should be chosen.