CS 2110 Homework 9
Dynamic Memory

Avaneesh Naren, Alice Zeng, Allison Fain, Irene Feijoo

Fall 2022

Contents

1 Overview

1.1 Purpose

The purpose of this assignment is to introduce you to dynamic memory allocation in C. You will also learn how to implement a singly-linked list data structure in C.

How do we allocate memory on the heap? How do we de-allocate it when it is no longer used?

The goal of this assignment is to learn how to dynamically allocate and de-allocate memory, or manage memory, in C.

1.2 Task

In this assignment, you will be implementing a singly-linked list data structure. Your linked list nodes will have struct data (of type User*). Each User struct contains a union with data for either a Student or an Instructor. You can find details about this struct and the contained union in the included **list.h** file. Your linked list will be able to add, remove, and mutate, and query the data stored within it.

You will be writing code in

1. list.c
2. main.c

(main.c is only for your own testing purposes)

1.3 Criteria

You will be graded on your ability to implement the linked list data structure properly. Your implementation must be as described by each function's documentation. Your code must manage memory correctly, meaning it must be free of memory leaks.

Note: A memory leak is when a block of memory is allocated for some purpose, and never de-allocated before the program loses all references to that block of memory.

2 Instructions

2.1 Implementation Overview

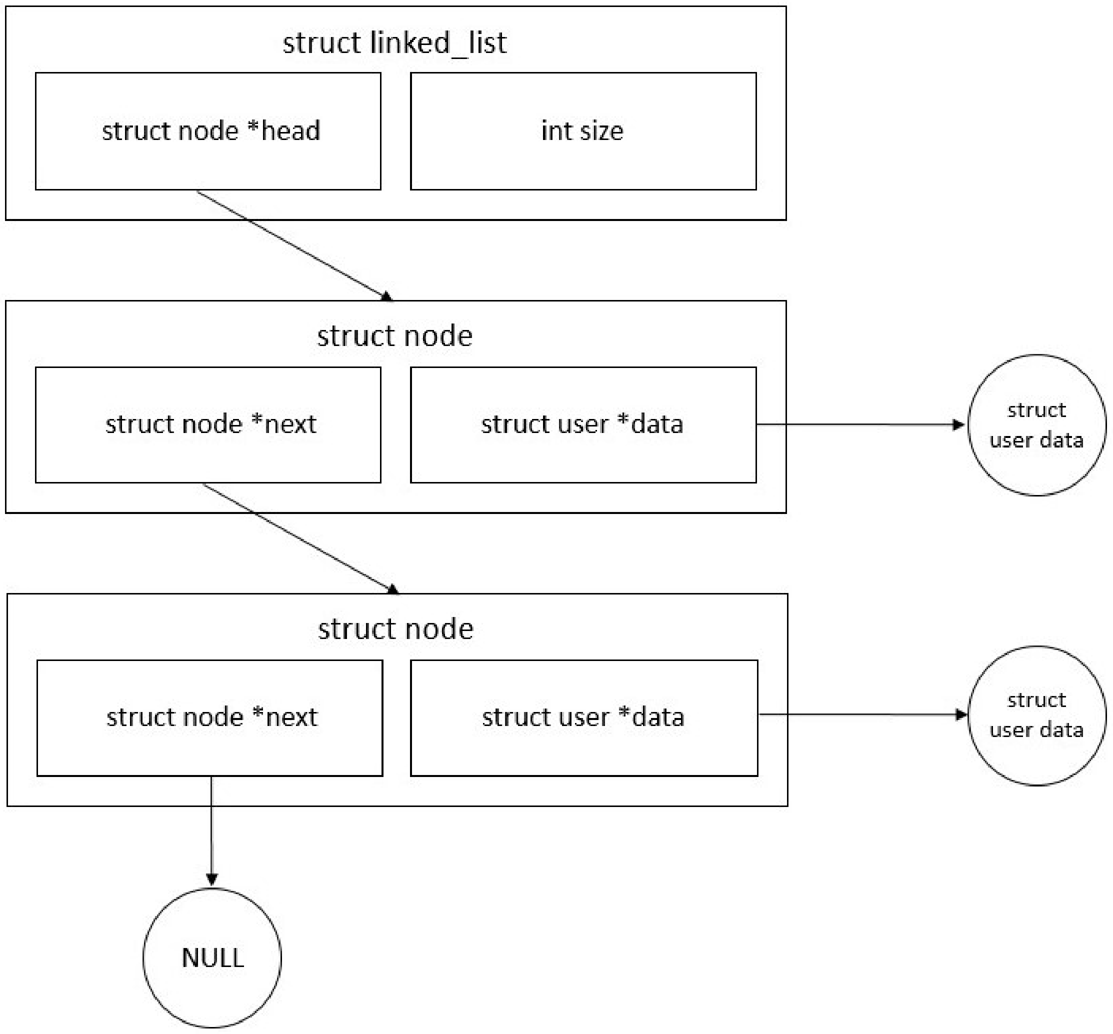
You have been given one C file - **list.c** in which to implement the linked list data structure. Implement all functions in this file. Each function has a block comment that describes exactly what it should do.

Be sure not to modify any other files. Doing so will result in point deductions that the tester will not reflect.

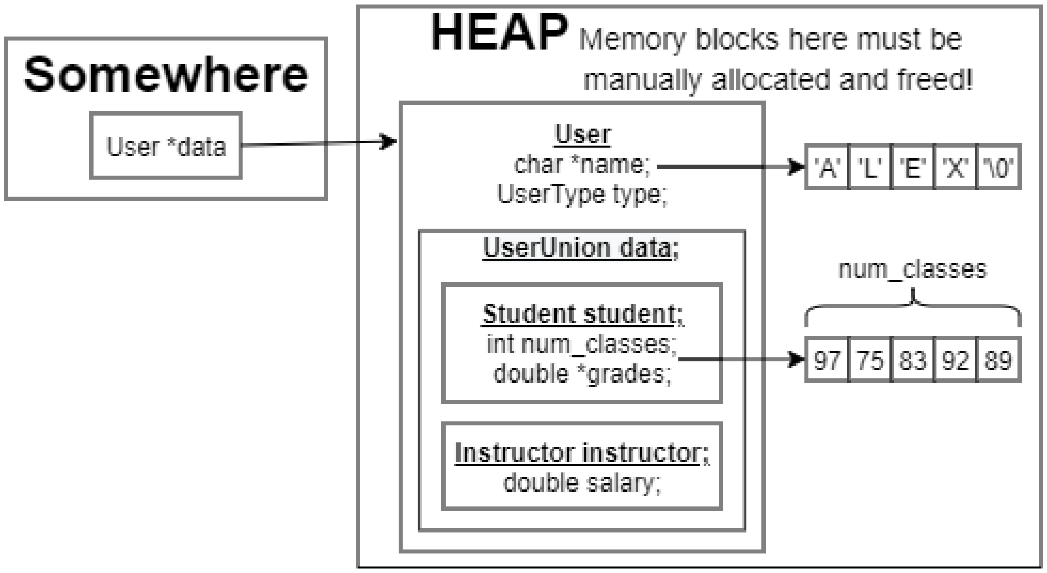
Remember that the struct data passed to certain functions (User *data) is malloc-ed data. However, this data is malloc-ed separately from the node structs that contain it.

Forgetting to free this data when it is removed can cause memory leaks (memory that's no longer being used but not freed), but freeing it when it should be returned to the user can created dangling pointers (memory that's freed but still being referenced). Keep this in mind when writing your list functions.

You are given a `struct linked_list`, which has a `head` pointer that points to the first node in the list and a `size` which represents the length of the linked list. You also have a `struct node` that has a `next` pointer to the next `list_node` and also a `User` pointer that points to a `User` in memory. Refer to the following diagram for a visual representation of `list` and `list_node`:



You may find the following graphic useful for understanding the pseudo-polymorphism used by `struct User` and `union UserUnion`:



Once you've implemented the functions in the list.c file, or after implementing a few, compile your code using the makefile. You may test your functions manually by writing your own test cases in the provided `main.c`, or run the autograder. See the Testing section below for more information.

Please COMPILE OFTEN. The compiler will reveal many syntax errors that you would rather find early before making them over and over throughout your code. Waiting until the end to compile for the first time will cause big headaches when you are trying to debug code. We speak from experience when we say compile often. :)

2.2 Implementation Tips

- Helper functions: There are three helper functions defined in **list.c**. You should use them to your advantage. NOTE: As seen in **list.c**, the helper functions are static, which means they are not part of the file's public interface and therefore will not be tested by the autograder. Improper implementations of these helpers may cause other tests to fail, so be sure to check them if your other functions fail any tests.
- Push/add functions: For these functions, make sure to read the documentation about what to do when malloc fails. In most cases, this means that you need to return 1 to indicate someting went wrong.
- Pop/remove functions: As we mentioned, you should free things that are no longer used to avoid memory leak, but you also don't want to free prematurely. Here, the potential candidates for freeing are: the nodes, the user data inside the node, the pointers inside the user. Think carefully about what you're doing in these functions (hint: look at return type) and figure out what should be freed.

2.3 Testing

Note: If you don't want to use the docker GUI, run the cs2110 docker script with the flag `-it`. This will connect to docker using only the terminal, which is all you need for this homework.

To compile and test your code, use the Makefile given as follows:

To manually test specific functions in your code, fill in the main function in `main.c` with tests, and run

```
make hw9
```

This will create an executable called hw9. Then, run the main function using

```
./hw9
```

To run the autograder, run

```
make run-tests
```

The local autograder does not test for memory leaks, though the one on gradescope does. To test your code for memory leaks locally, you will need to use valgrind.

To test your code using valgrind, run

```
make run-valgrind
```

3 Deliverables

Please upload the following files to Gradescope:

1. `list.c`

4 Demos

This homework will be demoed. The demos will be ten minutes long and will occur **IN PERSON**. Stay tuned for details as the due date approaches.

- Sign up for a demo time slot via Canvas **before** the beginning of the first demo slot. This is the only way you can ensure you will have a slot.
- If you cannot attend any of the predetermined demo time slots, e-mail the head TA Shawn Wahi (shawn.wahi@gatech.edu) **before** the week of demos.
- If you know you are going to miss your demo, you may cancel your slot on Canvas with no penalty, as long as you cancel 24 hours in advance. However, you are **not** guaranteed another time slot. If you cancel within 24 hours of your demo, it will be counted as a missed demo.
- Your overall homework score will be `((homework_score * 0.5) + (demo_score * 0.5))`, meaning if you received a 90% on your homework, but a 30% on the demo, you would receive an overall score of 60%. **If you miss your demo you will not receive any of these points, and the maximum you can receive on the homework is 50%.**
- You will be able to make up one of your missed demos at the end of the semester for half credit.

5 Appendix

5.1 Rules and Regulations

5.1.1 General Rules

1. Although you may ask TAs for clarification, you are ultimately responsible for what you submit. As such, please start assignments early, and ask for help early. This means that (in the case of demos) you should come prepared to explain to the TA how any piece of code you submitted works, even if you copied it from the book or read about it on the internet.
2. If you find any problems with the assignment it would be greatly appreciated if you reported them to the TAs. Announcements will be posted if the assignment changes.

5.1.2 Submission Guidelines

1. You are responsible for turning in assignments on time. This includes allowing for unforeseen circumstances. If you have an emergency let us know **IN ADVANCE** of the due time supplying documentation (i.e. note from the dean, doctor's note, etc). Extensions will only be granted to those who contact us in advance of the deadline and no extensions will be made after the due date.
2. You are also responsible for ensuring that what you turned in is what you meant to turn in. After submitting you should be sure to download your submission into a brand new folder and test if it works. No excuses if you submit the wrong files, what you turn in is what we grade. In addition, your assignment must be turned in via Canvas/Gradescope. Under no circumstances whatsoever we will accept any email submission of an assignment. Note: if you were granted an extension, you will still turn in the assignment over Canvas/Gradescope unless instructed otherwise.

5.1.3 Syllabus Excerpt on Academic Misconduct

Academic misconduct is taken very seriously in this class. Quizzes, timed labs and the final examination are individual work.

Homework assignments are collaborative. In addition many if not all homework assignments will be evaluated via demo or code review. During this evaluation, you will be expected to be able to explain every aspect of your submission. Homework assignments will also be examined using computer programs to find evidence of unauthorized collaboration.

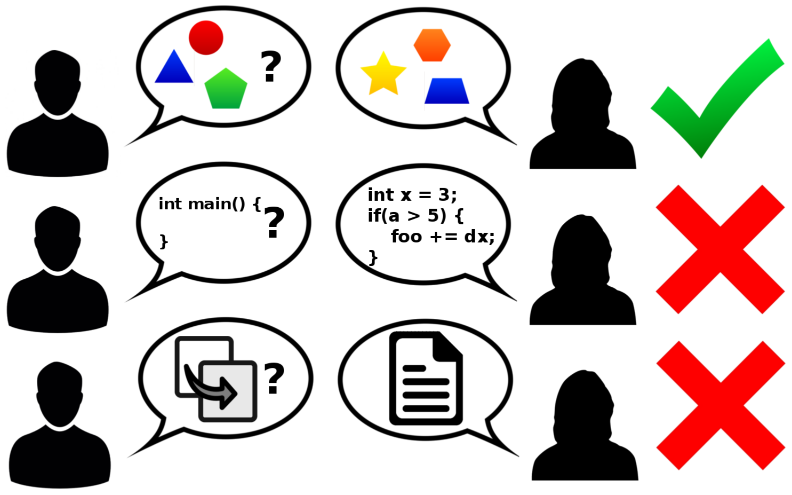
What is unauthorized collaboration? Each individual programming assignment should be coded by you. You may work with others, but each student should be turning in their own version of the assignment. Submissions that are essentially identical will receive a zero and will be sent to the Dean of Students' Office of Academic Integrity. Submissions that are copies that have been superficially modified to conceal that they are copies are also considered unauthorized collaboration.

You are expressly forbidden to supply a copy of your homework to another student via electronic means. This includes simply e-mailing it to them so they can look at it. If you supply an electronic copy of your homework to another student and they are charged with copying, you will also be charged. This includes storing your code on any site which would allow other parties to obtain your code such as but not limited to public repositories (Github), pastebin, etc. If you would like to use version control, use github.gatech.edu

5.1.4 Is collaboration allowed?

Collaboration is allowed on a high level, meaning that you may discuss design points and concepts relevant to the homework with your peers, share algorithms and pseudo-code, as well as help each other debug code.

What you shouldn't be doing, however, is pair programming where you collaborate with each other on a single instance of the code. Furthermore, sending an electronic copy of your homework to another student for them to look at and figure out what is wrong with their code is not an acceptable way to help them, because it is frequently the case that the recipient will simply modify the code and submit it as their own.


?
int main() {
}
?
int x = 3;
if(a > 5) {
foo += dx;
}
?