

Communication between towers

In recitation last week, we implemented a doubly linked list to be the underlying data structure for a stack. In this assignment, we will be implementing a communication network on top of a doubly linked list.

Background

In the Lord of the Rings trilogy, there is a scene where the first beacon is lit in the towers of Minas Tirith. The second beacon then sees the fire, and knows to light its fire to send a signal to the third beacon, and so forth. This was a means of communicating in the days before telegraphs were invented as it was much faster than sending a human rider to deliver a message. Communication towers were equipped with signaling mechanisms, such as mirrors, that could spell out messages using the positions of the mirrors.

Today, there are several examples of communication networks that are conceptually similar, but much more technically advanced, that route messages through multiple hubs between the sender and the receiver. For example, when you type a URL into a web browser, a request is sent through a network of service providers to the destination, and then packets of information are sent back to your machine. Say you type www.google.com from campus, your request may follow this path:

```
1 gateway (128.138.201.65)
2 biot-spsc.colorado.edu (128.138.81.2)
3 fw-biot.colorado.edu (128.138.81.250)
4 juniper-fw.colorado.edu (128.138.81.193)
5 frgp-i1-ucb.colorado.edu (198.59.55.10)
6 et-2-1-2.core-910.frgp.net (192.43.217.170)
7 72.14.194.239 (72.14.194.239)
8 108.170.252.193 (108.170.252.193)
9 74.125.251.199 (74.125.251.199)
10 den02s01-in-f4.1e100.net (172.217.11.228)
```

Each IP address is a hop in the network for the request, which is received at each service provider and then forwarded to the next service provider in the network, depending on the final destination of the message.

Build your own communications network

In this assignment, you're going to simulate a communications network using a linked list. Each node in your linked list will represent a city and you need to be able to send a message between nodes from one side of the country to the other. Your program also needs to provide the capability to update the network by adding cities and still be able to transmit the message. In this assignment, making changes to the network refers to updating the underlying linked list representing the network.

Include the following cities in your network:

Los Angeles
Phoenix
Denver
Dallas
St. Louis
Chicago
Atlanta
Washington, D.C.
New York
Boston

Implement each city as a struct with a name, a pointer connecting it to the next city in the network and the previous city in the network, and a place to store the message being sent. (You can assume the message is a string.) When you initially build your network, the order of the cities should be the same as the order listed above. After the network is built, you will provide the option of adding additional cities.

First, display a menu

When your program starts, you should display a menu that presents the user with options for how to run your program. The menu needs to look like the one shown here:

```
=====Main Menu=====
1. Build Network
2. Print Network Path
3. Transmit Message Coast-To-Coast-To-Coast
4. Add City
5. Delete City
6. Clear Network
7. Quit
```

The user will select the number for the menu option and your program should respond accordingly to that number. Your menu options need to have the following functionality.

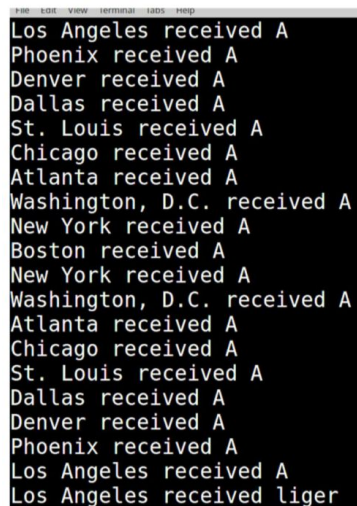
1. **Build Network:** This option builds the linked list using the cities listed above in the order they are listed. Each city needs to have a name, a pointer to the next city, a pointer to the previous city, and a message value, which will initially be an empty string. This option should be selected first to build the network, and can be selected anytime the user wants to rebuild the starting network after adding cities. As part of the Build Network functionality, you should print the name of each city in the network once the network is built in the following format:

NULL <- Los Angeles <-> Phoenix <-> Denver <-> Dallas <-> St. Louis <-> Chicago <-> Atlanta <->
Washington, D.C. <-> New York <-> Boston -> NULL

2. **Print Network Path:** This option prints out the linked list in order from the head to the tail by following the next pointer for each city. You should print the name of each city. The function could be very useful to you when debugging your code. The format should be the same as the format in Build Network.
3. **Transmit Message Coast-to-Coast-to-Coast:** This option reads word by word from the messageIn.txt file and transmits the message starting at the beginning of the network and ending at the end of the network, and then sends the message back again to the beginning of the network. Using the cities in this write-up, the message would go from Los Angeles to Boston, passing through each city along the way, and then back to Los Angeles, passing through each city along the way. When a city receives the message, you should print

<city name> received <word>

where <city name> is the name of the city and <word> is the word received. When a city receives a word, the word should be deleted from the sender city, i.e set the message for the sender city to an empty string. Here is a screenshot of the output I get after transmitting the first two words in the file:



```
Los Angeles received A
Phoenix received A
Denver received A
Dallas received A
St. Louis received A
Chicago received A
Atlanta received A
Washington, D.C. received A
New York received A
Boston received A
New York received A
Washington, D.C. received A
Atlanta received A
Chicago received A
St. Louis received A
Dallas received A
Denver received A
Phoenix received A
Los Angeles received A
Los Angeles received liger
```

Note: The name of the file that contains the message should be a command line argument to your program.

4. **Add City:** This option allows the user to add a new city to the network. If the user selects this option, then they should be prompted for the name of the city and the city that the new city should follow in the network. For example, if the user wants to add Tucson after Phoenix in the network, then the first four cities in the network would be:

Los Angeles <-> Phoenix <-> Tucson <-> Denver...

You don't need to print anything when you add a new city, just call the Print Network function again from the menu if you want to verify that the city has been added.

If the user wants to add a new city to the head of the network, e.g. replace Los Angeles as the starting city, then they should type “First” when prompted for the previous city and your code should handle this special case.

If the user wants to add a new city to the tail of the network, e.g. replace Boston as the tail city, then they should type “” when prompted for the previous city or the tail’s city name and your code should handle this special case.

Here is a screenshot showing the expected output for the add city functionality when the user selects Add City from the menu.

```
Enter a city name:
Tucson
Enter a previous city name:
Phoenix
=====Main Menu=====
1. Build Network
2. Print Network Path
3. Transmit Message Coast-To-Coast-To-Coast
4. Add City
5. Delete City
6. Clear Network
7. Quit
```

5. **Delete City:** This option allows the user to delete a city from the network. When the user selects this option, they should be prompted for the name of the city to delete. Your code should then update the next and previous pointers for the surrounding cities and free the memory for the deleted city.

```
5
Enter a city name:
Phoenix
```

6. **Clear Network:** This option allows the user to delete all cities in the network starting at the head city. After this functionality executes, the head of the list should be NULL and all cities should be deleted from the network. When a city is deleted, print the name of the city just before freeing the memory. Your clear network method should be called in the destructor of CommunicationNetwork, in addition to being a menu option.

```

6
deleting Los Angeles
deleting Phoenix
deleting Denver
deleting Dallas
deleting St. Louis
deleting Chicago
deleting Atlanta
deleting Washington, D.C.
deleting New York
deleting Boston

```

7. **Quit:** This option allows the user to exit the program.

For each of the options presented, after the user makes their choice and your code runs for that option, you should re-display the menu to allow the user to select another option.

Structuring your program

The specific cout statements that are expected are shown in Appendix A.

The functionality for your network will be implemented in a class called `CommunicationNetwork`. A suggested header file called `CommunicationNetwork.hpp` is provided for you on Moodle. Each of the menu options needs to be handled by calling methods in your `CommunicationNetwork` instance. You are welcome to write additional helper functions or methods (outside of the class) to support those provided. However **do not modify the given .hpp file**. Your code needs to be readable, efficient, and accomplish the task provided.

```

void CommunicationNetwork::addCity(string newCityName, string previousCityName)
/*Insert a new city into the linked list after the previousCityName. The name of the new
city is in the argument newCityName. */

```

```

void CommunicationNetwork::transmitMsg(char * filename)
/*Open the file and transmit the message between all cities in the network word by word. A word needs
to be received at the beginning of the network after being sent to the end of the network before
sending the next word (coast to coast to coast). Only one city can hold the message at a time; as soon as
it is passed to the next city, it needs to be deleted from the sender city. */

```

```

void CommunicationNetwork::printNetwork()
/*Start at the head of the linked list and print the name of each city in order to the end of the list. */

```

```

void CommunicationNetwork::buildNetwork()
/*Build the initial network from the cities given in this writeup. The cities can be fixed in the function,
you do not need to write the function to work with any list of cities. */

```

```

void CommunicationNetwork::deleteCity(std::string removeCity)

```

```
/*Find the city in the network where city name matches removeCity. Change the next and previous pointers for the surrounding cities and free the memory. */
```

```
void CommunicationNetwork::deleteNetwork()
```

```
/*Delete all cities in the network, starting at the head city. */
```

Suggestions for completing this assignment

There are several components to this assignment that can be treated independently. My advice is to tackle these components one by one, starting with printing the menu and getting user input. Next, build the network and print it. Then, add the functionality to add additional cities.

Once you get one feature completed, test, test, test, to make sure it works before moving on to the next feature.

There are several examples of how to work with linked lists in Chapter 5 in your book, and we will also be covering these concepts in lectures this week.

Your code should be separated into three files - *CommunicationNetwork.hpp*, *CommunicationNetwork.cpp*, and *Assignment3.cpp*. You need to write both the *CommunicationNetwork.cpp* and the *Assignment3.cpp* files. You can compile your code on the command-line using g++

```
g++ -std=c++11 CommunicationNetwork.cpp Assignment3.cpp -o Assignment3
```

and then run your program on the command-line using

```
./Assignment3 messageIn.txt
```

Also, start early.

What to do if you have questions

There are several ways to get help on assignments in 2270, and depending on your question, some sources are better than others. There is a discussion forum on Moodle that is a good place to post technical questions, such as how to shift an array. When you answer other students' questions on the forum, please do not post entire assignment solutions. The CAs are also a good source of technical information, especially questions about C++. If, after reading the assignment write-up, you need clarification on what you're being asked to do in the assignment, the TAs and the Instructor are better sources of information than the discussion forum or the CAs.

Appendix A – cout statements

Print path

```
cout << "===CURRENT PATH===" << endl;
cout<<"NULL <- ";

cout << tmp->name << " <-> "; //for all nodes in network

cout << tail->cityName << " -> ";
cout << "NULL" << endl;

cout << "======" << endl;
```

Transmit Message

```
cout<<receiver->cityName<<" received "<<receiver->message<<endl;

//if network not built yet, head = NULL
cout << "Empty list" << endl;
```

Adding a new city

```
cout << "Enter a city name: " << endl;
getline(cin,cityNewName);
cout << "Enter a previous city name: " << endl;
getline(cin,cityPreviousName);
```

Delete city

```
//if city name not found
cout<<cityNameIn<<" not found"<<endl;
```

Clear network

```
cout<<"deleting "<<tmp->cityName<<endl; //for all nodes in network
```

Print menu

```
cout << "====Main Menu====" << endl;
cout << "1. Build Network" << endl;
cout << "2. Print Network Path" << endl;
cout << "3. Transmit Message Coast-To-Coast-To-Coast" << endl;
cout << "4. Add City" << endl;
cout << "5. Delete City" << endl;
cout << "6. Clear Network" << endl;
cout << "7. Quit" << endl;
```

Quit

```
cout << "Goodbye!" << endl;
```