HW: Temperature Queries

Overview

Objectives

- Implement a linked list data structure.
- Practice using operator overloading to compare data.

Introduction

You are an amateur meteorologist tasked to develop a series of low-powered temperature querying devices for deploying onto the fields of small farming businesses, in order to provide better agricultural analytics at lower expenses. Due to the computing limitations of these deployed systems, you have decided to **implement the system using a linked list data structure for its lower memory footprint and faster runtime complexity**. In order to guide the design and development of the querying devices, you initially work with collected temperature data for reference. In this assignment, you implement the code that stores, accesses, and modifies temperature data in a linked list data structure.

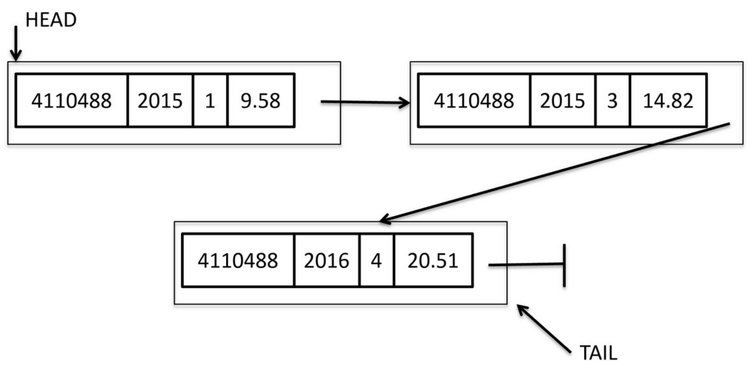
Getting Started

- Download the starter code.
  - **`LinkedList.h/cpp`** class definition for the linked list abstract data type.
  - **`Node.h/cpp`** class definition for the node (an element of the linked list).
  - **`TemperatureData.h/cpp`** class definition for temperature information.
  - **`TemperatureDatabase.h/cpp`** class definition for the database (manages a linked list)
  - **`main.cpp`** simple driver program.
- Download text files.
  - Input files.
  - Query files.
  - Results files.
- The requirements total **110 points** (10 bonus points are possible).
- Approved includes:
  - `iostream`
  - `sstream`
  - `string`
  - `fstream`
  - `limits`
  - `cstdlib`
  - `vector`
  - `ctime`
  - `LinkedList.h`
  - `Node.h`
  - `TemperatureData.h`
  - `TemperatureDatabase.h`
- Read over the requirements and refer to the appendix.

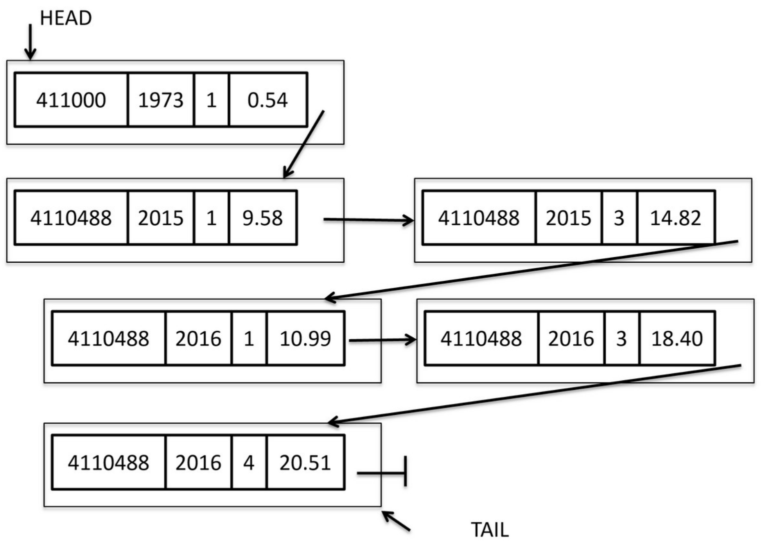
Requirements

Part 1 - Singly Linked List

- Your implementation has to use a linked list to store the data you read from the temperature file.
  - You *must* implement a function named "`getHead()`" in the class `LinkedList`. This function is supposed to return the pointer to the start `Node` of the list.
    - You should **not** use this function in any of your code since it is only there to assist autograding.
  - You *must* implement an overloaded `operator<` for the struct Node (and `TemperatureData` it calls) and you must use this operator to compare Nodes while inserting into the LinkedList. The nodes in the linked list are:
    - First ordered by location
    - Then by date *(i.e. by year and then by month)*
    - You do not have to worry about getting a duplicate entry for a month and year for a specific location.
  - For example, for the prior sample temps.dat, after reading 3 lines of the file your linked list looks like:



After reading all 7 lines from the file, it looks like:



Notice that we ignored the entry with value -99.99.

- Your program should receive the names of the input files as command line arguments. The first argument will be the temperature file, the second the queries file.
- If the input files contain a line with an invalid format, you should output an error message on the console (see examples below) and continue executing the program.
    - ***Do not*** throw an exception.
    - def
    - Examples of lines with invalid format for temps.dat:
      ```
      4111000 1889 0 -4.3
      4111000 1889 18 -4.3
      4111000 2016 01 -1222.11
      4111000 1889 .8 8.3
      4111000 2015 11
      ```
- You are required to use classes and comply with the “Rule of 3” (see zyBook and slides). More specifically, you need to implement the constructor, destructor, copy assignment, and copy constructor for the `LinkedList` class and any other class that uses the heap/freestore, but I don’t think any other class should use the heap.
    - The constructor for your `Node` and `TemperatureData` classes should take all data items (station id, year, month, average temperature value) as parameters. Use initialization in the “`membername(value)`” format (see zyBook and slides)
    - We’ll test these directly.
- Implement the print() function for the linked list. Use this function and/or the overloaded output operator to test your results. We’ll test the linked list functions directly for part 1. The expectation is that the list will be printed out in the correct order based on the comparison rules listed earlier.
    - Output format is the same as the format in the input file. Id, year, month, and temperature separated by a space.
    - When you output, it will look like the input file, with each item on one line. However, the order should be sorted according to the requirements above.
    - Formatting of floating point numbers will use what the ostream output operator (`<<`) does by default. Note that the formatting created by `atoi()` frequently does not match what the output operator does.

Part 2 - Bonus

- Your program should receive the names of the input files as command line arguments. The first argument will be the temperature file, the second the queries file.
- If the input files contain a line with an invalid format, you should output on the console an error message and finish executing the program.
    - Do not throw an exception.
    - Output the message in the console beginning `"Error: "` followed by the description shown below followed by the invalid value. For example:
        - Data File
            - Error: Invalid temperature `-1221.11`
            - Error: Invalid year `2024`
            - Error: Invalid month `0`
            - Error: Unable to open input.dat

            - Error: Other invalid input
        - Query File
            - Error: Invalid range `1996-1995`
            - Error: Unsupported query `MAX`
            - Error: Other invalid query
            - *Invalid years will be part of an invalid range*.
                - Error: Invalid range `1776-2025`
    - Examples of lines with invalid format for `queries.dat`:

      ```
      AVG 2015 2016
      411138 AVG 1996 1995
      411048 MODE 1500 2016
      411048 MAX 2015 2016
      ```
- The output file created by your program should be named **`result.dat`**.

Appendix

Background Information

A temperature file (e.g., temps.dat)

This file contains historic average temperatures for several locations in Texas. The data has been obtained from the United States Historical Climate Network (USCHN). Each line of the file contains a location, a date, and the average temperature (in Celsius) for that location and date. A **string**, corresponding to a meteorological station id, represents a location. For example, “411048” (string not number) corresponds to Brenham, Texas. A date is specified by two integers: a year and a month. A sample line in the temperature file would be:

- `410120 1893 2 6.41`

The temperature value -99.99 is used by the UCHN agency to represent missing information, for example:

- `410120 1893 1 -99.99`

Valid temperatures are assumed to be in the interval -50.0 to 50.0 (remember that they use Celsius, so this is a good range). The first valid year is 1800. The latest valid year should be our current year. You can declare a constant in your program to specify the current year. (If we were programming this to be used for real, we would instead obtain the current year from the system, so that no code changes are required for future years.) `temps.dat` might look like this:

```
411048 2015 1 9.58
411048 2015 3 14.82
411048 2016 4 20.51
411048 2016 1 10.99
411000 1973 1 0.54
411048 2016 3 18.40
411048 2016 5 -99.99
```

Extra Credit: A query file (e.g., `queries.dat`)

This file contains a list of queries (i.e., requests for information) that your program should calculate based on the data in file temps.dat. Each line in the file contains one query. There are two types of queries:

1. **AVG:** given a location (specified as a station id) and a range of years (specified as two integers, for example, `2000 2006`), it computes the average temperature for the location and period. If no data is available for the location/period, the answer will be the string “unknown”.
2. **MODE:** given a location and a range of years, it identifies the most common rounded temperature value in the period.
    - If no data is available for the period, the expected result is the string “unknown”.
    - If there is more than one mode, you should return the one with the highest value.
    - Notice that the temperature values in file temps.dat are double numbers. You should round these values to the nearest integer before computing the mode.For example, 8.03, 8.1, and 8.5 are all rounded to 8; 8.51 and 8.8 are rounded to 9. So with this set of data, there are three eights and two nines. And the mode would be 8.

Your program should read these two files and generate a file **result.dat** with the queries and their results. Regardless,

`temps.dat` might look like this:

```
411048 2015 1 9.58
411048 2015 3 14.82
411048 2016 4 20.51
411048 2016 1 10.99
411000 1973 1 0.54
411048 2016 3 18.40
411048 2016 5 -99.99
```

`queries.dat` might look like this:

```
411048 AVG 2015 2016
411138 AVG 1995 1995
411048 MODE 2015 2016
```

Then your program is expected to produce a file named **`result.dat`** with the following content:

```
411048 2015 2016 AVG 14.86
411138 1995 1995 AVG unknown
411048 2015 2016 MODE 21
```

Implementation Advice

Part 1

- Write a `myTest()` function for the `TemperatureDatabase`. You can call that function from main after loading the `Database` to test things like the rule of three, `print()`, etc.
- Use the `print()` function to print out your linked list so that you can make sure that you are maintaining it in order as required. First test with the small sample input files that we provide (e.g., first the one with 3 lines, then the one with 7 lines of data), output your linked list, and inspect it to see if it is representing the input data correctly.
- It is often a good idea to develop your solution incrementally.

Part 2 - Bonus

- When you round a double value to calculate the mode, make sure that you are not just truncating the value: the rounded value for 10.6 should be 11, not 10.
- Think about how you track the different temperatures for determining the mode. Note that you only have to keep track of values from -50 to 50. How many values is that?
- Notice that, as specified, the program you wrote is not very useful, as we often are not interested in average over years. We would prefer to be able to compare averages of specific months across year ranges. Once you complete your program, think about what you would have to do to be able to provide averages for specific months.
- If you tried your solution with very large input files, you may have noticed that your solution takes some time to provide the answers. Students in the Computer Science, Computing, and Computer Engineering majors have the opportunity to take many other courses (data structures, databases, computer systems,

operating systems, data mining, distributed systems, parallel computing) where they learn concepts and techniques to achieve efficient queries over large datasets.