Assignment 2: Virtual Filesystem

Data Structures (CS-UH 1050) — Spring 2021

1 Code of Conduct

All assignments are graded, meaning we expect you to adhere to the academic integrity standards of NYU Abu Dhabi. To avoid any confusion regarding this, we will briefly state what is and isn't allowed when working on an assignment.

Any documents and program code that you submit must be fully written by yourself. You can discuss your work with fellow students, as long as these discussions are restricted to general solution techniques. Put differently, these discussions should not be about concrete code you are writing, nor about specific results you wish to submit. When discussing an assignment with others, this should never lead to you possessing the complete or partial solution of others, regardless of whether the solution is in paper or digital form, and independent of who made the solution, meaning you are also not allowed to possess solutions by someone from a different year or course, by someone from another university, or code from the Internet, etc. This also implies that there is never a valid reason to share your code with fellow students, and that there is no valid reason to publish your code online in any form. Every student is responsible for the work they submit. If there is any doubt during the grading about whether a student created the assignment themselves (e.g. if the solution matches that of others), we reserve the option to let the student explain why this is the case. In case doubts remain, or we decide to directly escalate the issue, the suspected violations will be reported to the academic administration according to the policies of NYU Abu Dhabi (see https://students.nyuad.nyu.edu/campus-life/community-standards/policies/academic-integrity/).

2 Introduction

In this assignment, you will develop a virtual filesystem (VFS). A user can create/delete/move folders and files, among other operations described below. The filesystem should be organized as a Tree. Each **inode**[1] contains metadata about the node (e.g., file or folder, size, date). A folder can have zero or many folders and files, while a file is considered as a leaf node only. Deleting a file puts the inode's element in a limited size queue (the Bin/Trash) which can be emptied manually or automatically. The interface should allow a user to navigate and perform the described tasks below. At the beginning and end of the session, the file system is loaded, and dumped to the disk, respectively.

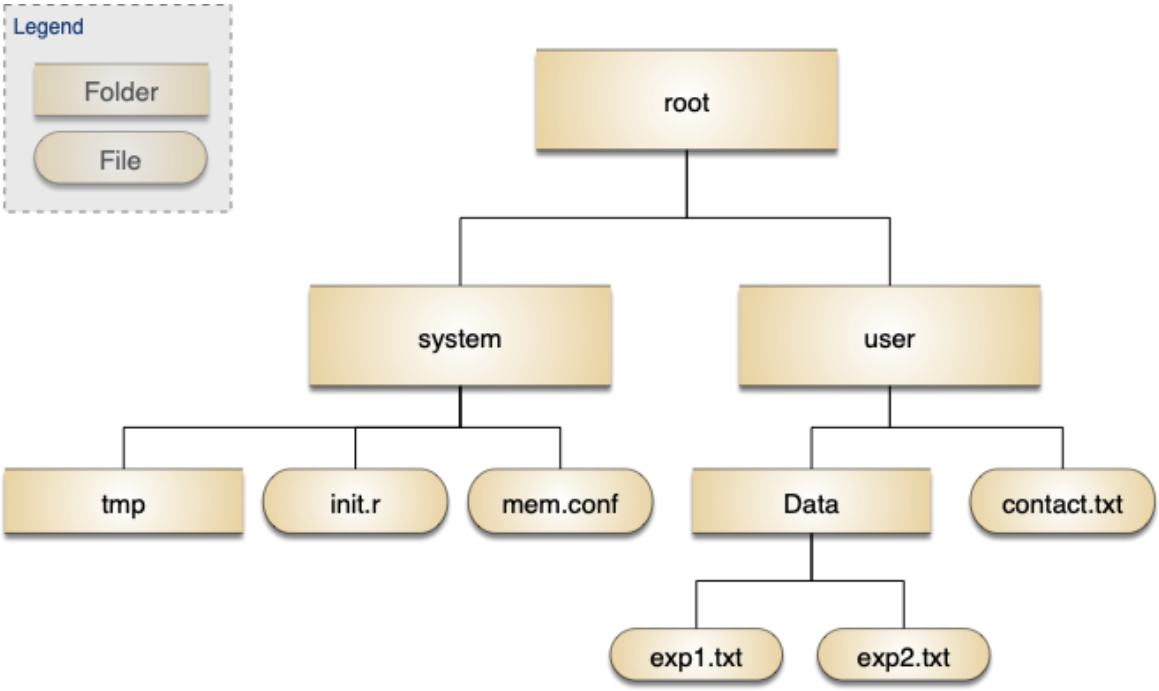
You are supposed to create a program utilizing object-oriented programming (OOP) principles and appropriate data structures discussed in class. **You should implement all the data structures manually, STL based containers are not allowed.**

[1] This is a reference to the actual unix style filesystem: https://en.wikipedia.org/wiki/Inode

3 Implementation

Overview:

Here is a visual example of the virtual filesystem at given state.



Storing the above state on disk will generate the following file.

vfs.dat

```
/,0,12-02-21
/system,10,12-02-21
/system/tmp,10,12-02-21
/system/init.r,150,12-02-21
/system/mem.conf,512,12-02-21
/user,10,12-02-21
/user/Data,10,01-03-21
/user/Data/exp1.txt,1886,01-03-21
/user/Data/exp2.txt,22232,01-03-21
/user/contact.txt,45,15-02-21
```

Constraints:

- The root inode has an empty element, and cannot be deleted. Printing the path of the root returns “/”.
- A file is an external inode, and cannot have subfolders.
- Filenames or Foldernames under a given inode must be unique.
- Each inode has a name (string), size (integer) and a date (system time).
- File names should be alphanumeric only (i.e. comprises the letters A to Z, a to z, and the digits 0 to 9) without whitespaces or special characters, except the period “.” that can be used for file extensions.
- The date of a file, is the system’s current date at creation.
- The default size of a **folder inode** is **10** bytes, except for the root whose size is **0** bytes.
- The **total size of a folde**r is the sum of all of its descendants (including its own).
- The size of a file is user specified at creation time (see the *touch* command).
- The path of an inode is the series of names of its ancestors including its own. Each name is preceded by a slash symbol “/”.
- Do not store the full path in an inode.
- **To simplify your implementation, use a single inode class/struct, and a boolean to specify its type.**

Commands to implement:

When your program starts, the user is greeted and presented with a prompt to enter one of the commands below. By default, the system is initiated at the root of the virtual filesystem. The user is able to interact with the system (using the commands) until an exit command is issued.

When the program starts, it loads a pre-existing filesystem structure from vfs.dat (see visual example above). If the file does not exist, assume starting from just a root inode.

As a user navigates through the file system, you must keep track of the **current** inode folder location.

*Note: in **blue** are user specified names or parameters*

1. **help**
   - Prints the following menu of commands.
2. **pwd**
   - Prints the path of current inode
   - Hint: Use a Stack based implementation
3. **realpath filename**
   - Prints the full path of a given file
4. **ls**
   - Prints the children of the current inode (if folder, error otherwise)
   - Each line shows: filetype (dir/file), filename, size, date
   - **ls sort**: order by descending file size, use bubble sort (extra 1 point 🦁)

5. **mkdir foldername**
    - Creates a folder under the current folder
6. **touch filename size**
    - Creates a file under the current inode location with the specified filename, size, and current datetime
7. **cd**
    - **cd foldername**: change current inode to the specified folder
    - **cd filename**: return an error
    - **cd ..** changes current inode to its parent folder
    - **cd -** changes current inode to the previous folder
    - **cd** changes current inode to root.
    - **cd /my/path/name** changes the current inode to the specified path if it exists
8. (**find foldername**) or (**find filename**)
    - Returns the path of the file (or the folder) if it exists
    - You should print all matching paths. The same name may exist in different locations
    - Starts the search from the root folder
9. **mv filename foldername**
    - Moves a file located under the current inode location, to the specified folder path
    - The specified file and folder have to be one of the current inode's children (an error is returned otherwise)
10. (**rm foldername**) or (**rm filename**)
    - Removes the specified folder or file and puts it in a Queue of MAXBIN=10
    - The specified file or folder has to be one of the current inode's children (an error is returned otherwise)
    - Hint: Use a Queue based implementation
11. Implement **mv** and **rm** on *arbitrary* inode locations. (Bonus point 0.5 each 🦁)
    - The inode and destination folder are specified using a path
    - Examples:
        - **mv /user/contact.txt /system/tmp**
        - **mv /user/tmp /user/**
        - **rm /user/contact.txt**
        - **rm /user/tmp**
12. **size foldername** or **filename**
    - Returns the total size of the folder (including all its subfiles), or the size of the file
13. **emptybin**
    - Empties the bin
14. **showbin**
    - Shows the oldest inode of the bin (including its path)
15. **recover** (Bonus 0.5 point 🦁)
    - Reinstates the oldest inode back from the bin to its original position in the tree (if the path doesn't exist anymore, an error is returned)
16. **Exit**
    - The program stops and the filesystem is saved in the described format.

Example:

The above example filesystem was created from scratch using the following commands:

```
> mkdir system
> mkdir user
> cd system
> mkdir tmp
> touch init.r 150
> touch mem.conf 512
> cd ..
> cd user
> mkdir Data
> touch contact.txt 45
> cd Data
> touch exp1.txt 1886
> touch exp2.txt 22232
```

Additional operations are demonstrated below:

```
> find exp1.txt
/user/Data/exp1.txt
> size /
123123 bytes
> size /user/Data
24865 bytes
> cd /user/Data
> pwd
/user/Data
> rm exp1.txt
> showbin
Next Element to remove: /user/Data/exp1.txt (1886 bytes, 01-03-21)
> emptybin
> showbin
The bin is empty
> cd
> pwd
/
> ls
dir  system 12-02-21 10bytes
dir  user 12-02-21 10bytes
> cd -
> pwd
/user/Data
> ls
dir Data 01-03-21 10bytes
file contact.txt 15-02-21 45bytes
> ls sort
file contact.txt 15-02-21 45bytes
dir Data/ 01-03-21 10bytes
> size /user/Data
22232 bytes
> mv contact.txt Data
> ls
dir Data 01-03-21 10bytes
> size /user/Data
22277 bytes
> cd Data
> ls
file contact.txt 15-02-21 45bytes
file exp2.txt 01-03-21 22232bytes
```

3 Grading

Description	**Score (/20)**
Initialization: - Loading, reading, dumping the system files correctly - Defining the main/additional classes correctly, with their attributes+methods - Creating objects from each class correctly - Using the appropriate data structure implementations vectors/lists/array/tree/queue/stack ○ Implement main data structures yourself; don't use STL Lists. - Overall, properly implementing every data structure in the program	8
Proper implementation of the terminal interface, which should allow users to issue the required commands.	8
Proper error handling of missing and invalid input, etc.	2
Documentation (code comments)	2

Extra points (🦁) are used to pad your score up to the maximum score, but the total cannot exceed 20 points.

You should solve and work **individually** on this assignment. The deadline of this assignment is **after 14 days of its release** on NYU Brightspace.

You should directly submit your C++ source files (*.cpp, *.hpp) and Makefile (if any) on NYU Brightspace. Submissions via email are unacceptable.

Late submissions will be accepted only up to 2 days late, afterwards you will receive zero points. All assignments are due at 11:59 pm on the due date. For late submissions, 5% will be deducted from the homework grade per late day.

Note that your program should be written in C++ and **must be runnable on the Linux, Unix or macOS operating system**.