

**COSC 4740**  
**Final Project**

Due date: Dec 02

*I hear and I forget, I see and I remember, I do and I understand.* - Chinese proverb

Goal: To design and implement a subset of the Unix file system.

Grade: 30% of your total grade is allocated for this project. All the files you will need are in the repo, so your group must create the repo first. READ EVERY FILE, there is lots of information in the code and other files included. Failure to read everything is your failure and likely lot of time and points.

The filesystem consists of five classes:

1. *Disk*: Simulates the behavior of a disk that is used to store files and other filesystem information.
2. *DiskManager*: Partitions and manages access to a disk.
3. *PartitionManager*: Manages partitions in a disk.
4. *FileSystem*: Implements various filesystem operations.
5. *Client*: Uses a filesystem.

### **Disk**

Simulates the behavior of a disk using a Unix file. It exports the following functions:

```
int initDisk()
int readDiskBlock(int blknum, char *blkdata)
int writeDiskBlock(int blknum, char *blkdata)
int getBlockSize()
int getBlockCount()
```

The first function creates a Unix file to simulate a disk. If such a file already exists, it returns 0, otherwise it creates the file of specified size and returns 1. The second function reads the disk block numbered *blknum* into the buffer pointed to by *blkdata*. The third function copies the buffer pointed to by *blkdata* to the disk block numbered *blknum*. Both of these functions return 0 if successful and a negative number otherwise. Every Disk object is managed by a DiskManager object.

### **DiskManager**

Partitions and manages access to a disk. There is one DiskManager object associated with each Disk object. A DiskManager object partitions a disk into multiple partitions, and provides some of the basic functions needed by a filesystem to store its information. These functions are:

```
int readDiskBlock(char partitionname, int blknum, char *blkdata)
int writeDiskBlock(char partitionname, int blknum, char *blkdata)
int getBlockSize()
int getPartitionSize(char partitionname)
```

`readDiskBlock` reads the partition block numbered *blknum* into the buffer pointed to by *blkdata*. `writeDiskBlock` copies the buffer pointed to by *blkdata* to the

partition block numbered *blknum*. `getBlockSize` return the size of a disk block in bytes. `getPartitionSize` returns the total number of blocks available in this partition.

## **PartitionManager**

A `PartitionManager` object manages partitions in a disk. A `PartitionManager` object is created by a `FileSystem` object (described next) and has a partition name associated with it. Each `PartitionManager` object is associated with a `DiskManager` object. Each `PartitionManager` has a bitmap that keeps track of free and allocated blocks. The bitmap is written out block 0 of the partition. It exports the following operations:

`int readDiskBlock(int blknum, char *blkdata)`

`readDiskBlock` reads the block numbered *blknum* in a disk partition into the buffer pointed to by *blkdata*.

`int writeDiskBlock(int blknum, char *blkdata)`

This operation copies the buffer pointed to by *blkdata* to the block numbered *blknum* in a disk partition.

`int getBlockSize()`

This operation returns the size of a disk block in bytes.

`int getFreeDiskBlock()`

This operation allocates a free disk block in a partition. It returns -1 if there is no block available (ie the partition is full) or the block number allocated.

`int returnDiskBlock(int blknum)`

This operation deallocates a disk block in a partition. It will also write a blank (all #'s) to the block that is returned. It returns 0 if successful or -1 for any other reason.

## **FileSystem**

A `FileSystem` object implements a Unix file system. Each `FileSystem` object is associated with a `DiskManager` object, which it uses for all disk I/O. Multiple `FileSystem` objects may be associated with a single `DiskManager` object, which implies that multiple file systems can share a disk. This is equivalent to partitioning of a single disk drive into multiple directories in modern systems. Each partition is managed by a `PartitionManager` object, which is created by a `FileSystem` object.

Files and directories are implemented using a structure similar to the Unix i-nodes. There are three i-nodes: File i-node, directory i-node, and indirect inode. Every file in the file system has a file i-node associated with it. A file i-node will contain the following information: file name (1 byte), a 1 byte variable to indicate whether it is a file or a directory, file size (4 bytes), three disk block addresses (4 bytes each), and one single indirect block address (4 bytes). Use the remaining bytes in the block to store some other file attributes of your choice. An indirect block is 64 bytes (same as block size), with 16 spots for disk block addresses (4 bytes each). A directory i-node has the following structure, 64 bytes, with 10 slots containing: name (1 byte), block pointer (4 bytes), type file/directory (1 byte) and the last 4 bytes a pointer to the next block with the directory

information will continue if needed. A FileSystem object exports the following operations:

```
int createFile(char *filename, int fname_len)
```

This operation creates a new file whose name is pointed to by *filename* of size *fname\_len* characters. File names and directory names start with '/' character and consist of a sequence of alternating '/' and alphabet ('A' to 'Z' and 'a' to 'z') characters ending with an alphabet character. The CreateFile function returns -1 if the file already exists, -2 if there is not enough disk space, -3 if invalid filename, -4 if the file cannot be created for some other reason, and 0 if the file is created successfully.

```
int createDirectory(char *dirname, int dnameLen)
```

This operation creates a new directory whose name is pointed to by *dirname*. This function returns -1 if the directory already exists, -2 if there is not enough disk space, -3 if invalid directory name, -4 if the directory cannot be created for some other reason, and 0 if the directory is created successfully.

```
int lockFile(char *filename, int fname_len)
```

This operation locks a file. A file cannot be locked if (1) it doesn't exist, or (2) it is already locked, or (3) it is currently opened. It returns a number greater than 0 (lock id), if the file is successfully locked, -1 if the file is already locked, -2 if the file does not exist, -3 if it is currently opened, and -4 if the file cannot be locked for any other reason. A note, once a file is locked, it may only be opened with the lock id and the file cannot be deleted or renamed until the file is unlocked.

```
int unlockFile(char *filename, int fname_len, int lock_id)
```

This operation unlocks a file. The *lock\_id* is the lock id returned by the LockFile function when the file was locked. The UnlockFile function returns 0 if successful, -1 if lock id is invalid, -2 for any other reason.

```
int deleteFile(char *filename, int fname_len)
```

This operation deletes the file whose name is pointed to by *filename*. A file that is currently in use (opened or locked by a client) cannot be deleted. It returns -1 if the file does not exist, -2 if the file is in use or locked, -3 if the file cannot be deleted for any other reason, and 0 if the file is deleted successfully.

```
int deleteDirectory(char *dirname, int dnameLen)
```

This operation deletes the directory whose name is pointed to by *dirname*. Only an empty directory can be deleted. This function returns -1 if the directory does not exist, -2 if the directory is not empty, -3 if the directory cannot be deleted for any other reason, and 0 if the directory is deleted successfully.

```
int openFile(char *filename, int fname_len, char mode, int lock_id)
```

This operation opens a file whose name is pointed to by *filename*. If mode = 'r', the file is opened for read only, If mode = 'w', the file is opened for

write only, and if mode = 'm', the file is opened for read and write. An existing file cannot be opened if (1) the file is locked and lock\_id doesn't match with lock\_id returned by the **lockFile** function when the file was locked, or (2) the file is not locked and lock id  $\neq$  -1. This operation returns -1 if the file does not exist, -2 if mode is invalid, -3 if the file cannot be opened because of locking restrictions, -4 for any other reason, and a unique positive integer (file descriptor) if the file is opened successfully. If the file is opened successfully, an rw pointer (read-write pointer) is associated with this file descriptor. This rw pointer is used by some of the operations described later for determining the access point in a file. The initial value of an rw pointer is 0 (beginning of the file).

```
int closeFile(int filedesc)
```

This operation closes the file with file descriptor *filedesc*. It returns -1 if the file descriptor is invalid, -2 for any other reason, and 0 if successful.

```
int readFile(int filedesc, char *data, int length)  
int writeFile(int filedesc, char *data, int length)  
int appendFile(int filedesc, char *data, int length)
```

These operations perform read/write/append operations on a file whose file descriptor is *filedesc*. *length* is the number of bytes to be read from / written into / appended into the buffer pointed to by *data*. These operations return -1 if the file descriptor is invalid, -2 if length is negative, -3 if the operation is not permitted, and number of bytes read/written/appended if successful. The read and write operations operate from the byte pointed to by the rw pointer. The write operation overwrites the existing data in the file and may increase the size of the file. The append operation appends the data at the end of the file. The read operation may read less number of bytes than length if end of file is reached earlier. After the read/write/append is done, the rw pointer is updated to point to the byte following the last byte read/written/appended.

```
int seekFile(int filedesc, int offset, int flag)
```

This operation modifies the rw pointer of the file whose file descriptor is *filedesc*. The rw pointer is moved *offset* bytes forward if flag = 0. Otherwise, it is set to byte number offset in the file. This operation returns -1 if the file descriptor, *offset* or *flag* is invalid, -2 if an attempt to go outside the file bounds is made (end of file or beginning of file), and 0 if successful. A negative offset is valid only when flag is zero.

```
int truncFile(int filedesc, int offset, int flag)
```

This operation will delete the file contents from the point of the rw pointer of the file whose file descriptor is *filedesc*. The rw pointer is moved *offset* bytes forward if flag = 0. Otherwise, it is set to byte number offset in the file. A negative offset is valid only when flag is zero. This operation returns -1 if the file descriptor, *offset* or *flag* is invalid, -2 if an offset moves the rw pointer outside the file bounds (end of file or beginning of file), -3 if the mode is read. Otherwise, the return value is number of bytes deleted.

```
int renameFile(char *fname1, int fname1_len, char *fname2, int fname2_len)
```

This operation changes the name of the file whose name is pointed to by *fname1* to the name pointed to by *fname2*. It returns -1 invalid filename, -2 if the file does not exist, -3 if there already exists a file whose name is the same as the name pointed to by *fname2*, -4 if file is opened or locked, -5 for any other reason, and 0 if successful.

```
int renameDirectory(char *dname1, int dname1_len, char *dname2, int dname2_len)
```

This operation changes the name of the file whose name is pointed to by *dname1* to the name pointed to by *dname2*. It returns -1 invalid directory name, -2 if the directory does not exist, -3 if there already exists a directory whose name is the same as the name pointed to by *dname2*, -4 for any other reason, and 0 if successful.

```
int getAttributes(char *filename, ...)
```

```
int setAttributes(char *filename, ...)
```

These operations get/set the attributes of a file whose name is pointed to by *filename*. Work out the details of these operations based on the file attributes you choose. You must choose a minimum of **two** attributes for your filesystem.

### **Client**

This class is used to create client objects that invoke file system operations. Each Client object is associated with a FileSystem object.

### Implementation Guidelines

1. Implement your file system using C++.
2. Unix file system commands are used to implement the Disk. No other functions should use any Unix file system functions.
3. Use bitmaps to keep track of free disk blocks. The bitvector code is provided and is to be used to implement the bitmaps.
4. Some support files are provided to you to get started. These include *bitvector.h* and *bitvector.cpp* that implement a *BitVector* class, *disk.h* and *disk.cpp* that implement a *Disk* class. The rest of the code is in *.cpp* and *.h* files. Some methods may be filled out already, others are just blank methods. In addition, an outline of a driver program to test the file system is provided in file *driver.cpp*. *Driver1.cpp* through *driver8.cpp* are used when turning in the project. All these files are available via your github project repo.
5. Remember that your file system should survive the termination of clients that are using it.
6. Don't code until you understand what you are doing. Design, design, design first. While weeks of programming can save you hours of planning, I don't advise it.
7. Start working on this project now. First complete the implementation of *DiskManager* class.
8. Make sure you read everything, first! There is a lot of information in the *cpp* and header files and in other files provided.

### **Project Submission notes:**

1. You will do this project in teams of up to three students. Groups will be chosen at random.
  - You will turn in a separate evaluation of each member of your group, which is worth 5 points each (of 100) for the project. See the hard copy section.
  - As note, you are responsible for submitting the final project irrespective of how your team partner's work.
2. You are expected to make at least one update a week before the project is due. Even if it only to update the readme, to add WE DID NOTHING THIS WEEK.
3. You are all expected to use github. Each group member must make at least one commit. I suggest you use the issue system as well, but it's not required.
4. Update the README.md file in the root directory.
  - Include all the names of the group at the top of the readme.
  - Include what is working and not working. This is detail how much of the project is completed and working. Say for example you only get to driver4 completed and working, then you should state that.
  - Including any information about the file attributes you choose for driver8 as well.
5. You will use the makefile to compile your code in the project directory. If you change/add something, then it MUST be reflected in the makefile as well. If the makefile doesn't work/compile the project, then your project doesn't compile, and you will lose half the points (which is 15% of your final grade too). Only the main branch will be used. All warnings are to be cleaned up as well.
6. Lastly, the project will be graded by looking at DISK1 after each driverX run. And then at the code itself. It is highly suggested you spend a lot of time with a hex editor looking at the disk to ensure it is correct.

### **Hard copy:**

There will be two separate things turned in.

First

Cover Page Designate one person for this, if your group cannot agree, then everyone does it.

1. A cover page with Names of all Group members, Final Project, cosc 4740 a repo name (see github and below for your repo name).
2. Hardcopy of all the driver output (of the working drivers).
3. Attach the output of the drivers (well only the working drivers)

Second

Each person will fill out and submit an evaluation document for each group member. The evaluation document is provided in the repo. It will list what you did and what the rest of the group members did as well. This doesn't have to be very long. Describe how the project was broken up and who did what. DO NOT COMMIT OR PUSH THIS DOCUMENT TO GITHUB. Only print the evaluation pages, not the rubric pages.

**Soft copy:**

1. Use this link to create your (group)  
<https://classroom.github.com/a/L4u1Hzva>
2. Upload the project to your repo (and to correct directories).
3. See submission issue #3 commits and #4 to fill out the readme file.
4. Lastly ensure everything has uploaded to the github website and not just the local repo. Remember only the main branch will be pulled.

Code will be graded on correctness, comments, and coding style.