FAT32 Utility Operations Guide

Classes COP4610 / CGS5765

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Outline

- Directory entries
  - Short-name and long-name entries
- *Read-only* project 3 operations
- Other *non-read-only* project 3 operations

Directory Entries

Directory Entries

- Lists names of files and directories in a directory
- Types
  - Short-name directory entry
  - Long-name directory entry

Short-name Directory Entry

- Limits name size to 8 bytes with additional 3 bytes after "."
- Compatible with previous FAT versions
- 32 bytes total size
- Holds important information about file or dir:
  - Attributes, timestamp, last access date, first cluster number, size

Short-name Directory Entry

- FAT32 Directory Entry Structure

Name	Offset (byte)	Size (bytes)	Description
DIR_Name	0	11	Short Name
DIR_Attr	11	1	File Attributes (More on it later)
DIR_NTRes	12	1	Reserved for Windows NT
DIR_CrtTimeTenth	13	1	Millisecond stamp at file creation time
DIR_CrtTime	14	2	Time file was created
DIR_CrtDate	16	2	Date file was created

Short-name Directory Entry

- FAT32 Directory Entry Structure

Name	Offset (byte)	Size (bytes)	Description
DIR_LstAccDate	18	2	Last access date
DIR_FstClusHI	20	2	High word of this entry's first cluster number
DIR_WrtTime	22	2	Time of last write
DIR_WrtDate	24	2	Date of last write
DIR_FstClusLO	26	2	Low word of this entry's first cluster number
DIR_FileSize	28	4	32-bit DWORD holding this file's size in bytes

Short-name Directory Entry

Bit	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Attribute	Reserved. Set to 0		Archive	Directory	Volume ID	System	Hidden	Read-only

- For example, if the bit 4 is set to 1, you know the entry is for a sub-directory, instead of a file.

Short-name Directory Entry

- Check **page 23** on FAT32 Spec document for detailed descriptions
- For the correct implementation of this project, setting *DIR_name, DIR_Attr, DIR_FstClusHI, DIR_FstClusLO, DIR_FileSize* correctly is essential
- You may lose a point or two if you don’t set the other fields correctly

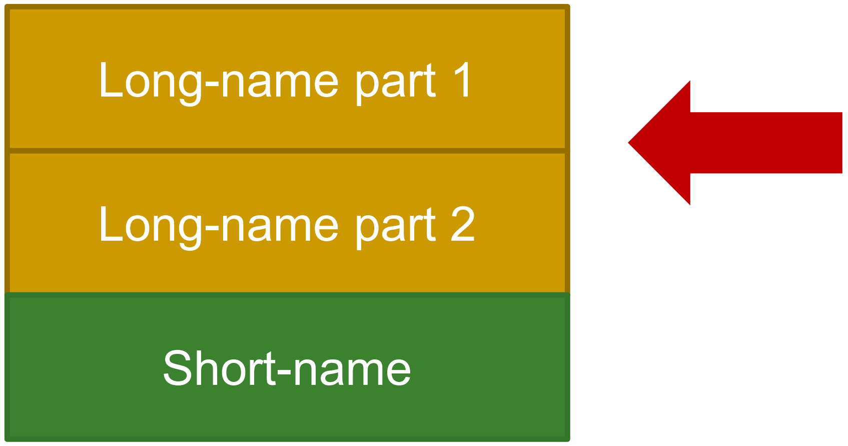
Short-name Directory Entry

- If DIR_Name[0] == 0xE5, then the directory entry is free (no file or directory name in this entry)
- If DIR_Name[0] == 0x00, then the directory entry is free (same as for 0xE5), and there are no allocated directory entries after this one

Long-name Directory Entry

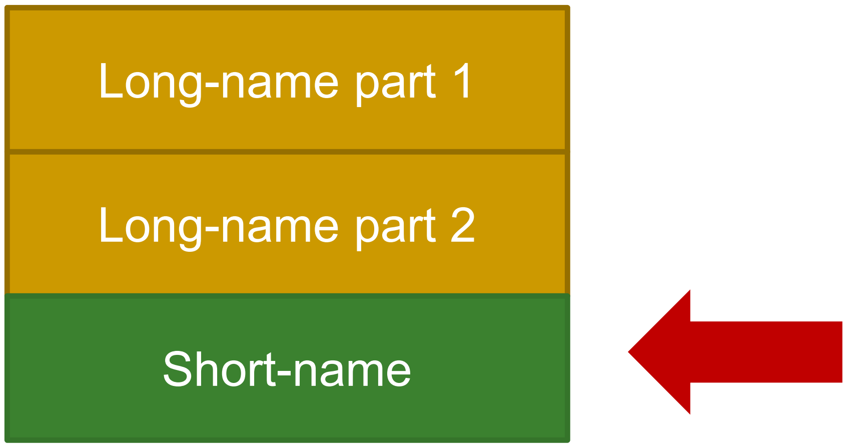
- Backwards-compatible way to allow longer names to be displayed
- Each long-name directory entry is 32 bytes
  - A long file name can cover a ***set*** of long-name directory entries
- Each set of long-name directory entries must correspond to a short-name directory entry
  - Long-name entries must immediately precede corresponding short-name entry

Long-name Directory Entry



In this example case, two long-name entries are needed to hold the file name

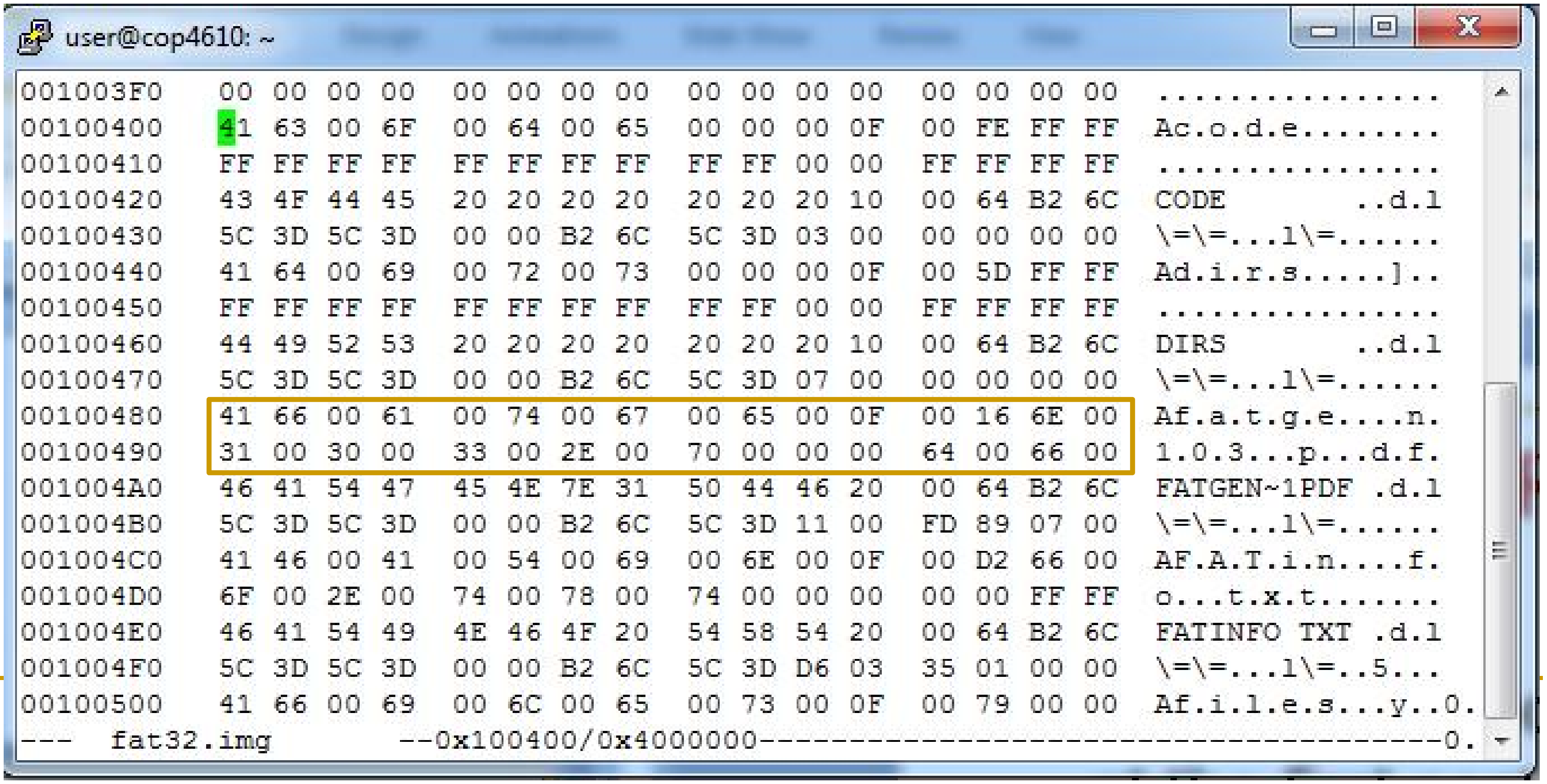
Long-name Directory Entry



Short name entry for the file must exist too, and it immediately follows the long name entry(s)

Directory entries

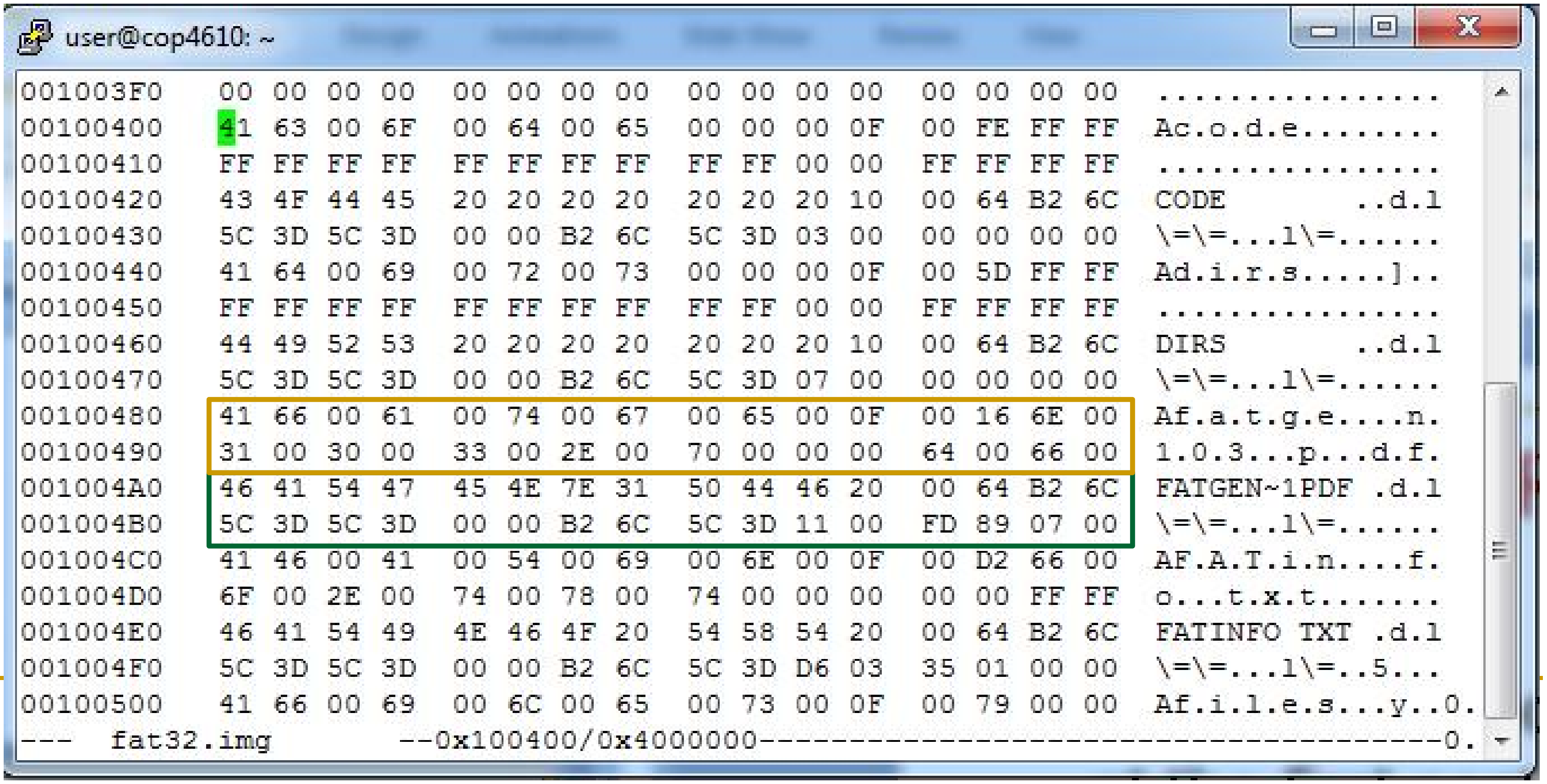
- Long-name entry for “fatgen103.pdf"


user@cop4610: ~

```
001003F0    00 00 00 00  00 00 00 00  00 00 00 00  00 00 00 00   ................
00100400    41 63 00 6F  00 64 00 65  00 00 00 0F  00 FE FF FF   Ac.o.d.e........
00100410    FF FF FF FF  FF FF FF FF  FF FF 00 00  FF FF FF FF   ................
00100420    43 4F 44 45  20 20 20 20  20 20 20 10  00 64 B2 6C   CODE       ..d.l
00100430    5C 3D 5C 3D  00 00 B2 6C  5C 3D 03 00  00 00 00 00   \=\=...l\=......
00100440    41 64 00 69  00 72 00 73  00 00 00 0F  00 5D FF FF   Ad.i.r.s.....]..
00100450    FF FF FF FF  FF FF FF FF  FF FF 00 00  FF FF FF FF   ................
00100460    44 49 52 53  20 20 20 20  20 20 20 10  00 64 B2 6C   DIRS       ..d.l
00100470    5C 3D 5C 3D  00 00 B2 6C  5C 3D 07 00  00 00 00 00   \=\=...l\=......
00100480    41 66 00 61  00 74 00 67  00 65 00 0F  00 16 6E 00   Af.a.t.g.e....n.
00100490    31 00 30 00  33 00 2E 00  70 00 00 00  64 00 66 00   1.0.3...p...d.f.
001004A0    46 41 54 47  45 4E 7E 31  50 44 46 20  00 64 B2 6C   FATGEN~1PDF .d.l
001004B0    5C 3D 5C 3D  00 00 B2 6C  5C 3D 11 00  FD 89 07 00   \=\=...l\=......
001004C0    41 46 00 41  00 54 00 69  00 6E 00 0F  00 D2 66 00   AF.A.T.i.n....f.
001004D0    6F 00 2E 00  74 00 78 00  74 00 00 00  00 00 FF FF   o...t.x.t.......
001004E0    46 41 54 49  4E 46 4F 20  54 58 54 20  00 64 B2 6C   FATINFO TXT .d.l
001004F0    5C 3D 5C 3D  00 00 B2 6C  5C 3D D6 03  35 01 00 00   \=\=...l\=..5...
00100500    41 66 00 69  00 6C 00 65  00 73 00 0F  00 79 00 00   Af.i.l.e.s...y..0.
---  fat32.img      --0x100400/0x4000000-------------------------------------0.
```

Directory entries

- Short-name entry for “fatgen103.pdf"



user@cop4610: ~

```
001003F0    00 00 00 00  00 00 00 00  00 00 00 00  00 00 00 00   ................
00100400    41 63 00 6F  00 64 00 65  00 00 00 0F  00 FE FF FF   Ac.o.d.e........
00100410    FF FF FF FF  FF FF FF FF  FF FF 00 00  FF FF FF FF   ................
00100420    43 4F 44 45  20 20 20 20  20 20 20 10  00 64 B2 6C   CODE       ..d.l
00100430    5C 3D 5C 3D  00 00 B2 6C  5C 3D 03 00  00 00 00 00   \=\=...l\=......
00100440    41 64 00 69  00 72 00 73  00 00 00 0F  00 5D FF FF   Ad.i.r.s.....]..
00100450    FF FF FF FF  FF FF FF FF  FF FF 00 00  FF FF FF FF   ................
00100460    44 49 52 53  20 20 20 20  20 20 20 10  00 64 B2 6C   DIRS       ..d.l
00100470    5C 3D 5C 3D  00 00 B2 6C  5C 3D 07 00  00 00 00 00   \=\=...l\=......
00100480    41 66 00 61  00 74 00 67  00 65 00 0F  00 16 6E 00   Af.a.t.g.e....n.
00100490    31 00 30 00  33 00 2E 00  70 00 00 00  64 00 66 00   1.0.3...p...d.f.
001004A0    46 41 54 47  45 4E 7E 31  50 44 46 20  00 64 B2 6C   FATGEN~1PDF .d.l
001004B0    5C 3D 5C 3D  00 00 B2 6C  5C 3D 11 00  FD 89 07 00   \=\=...l\=......
001004C0    41 46 00 41  00 54 00 69  00 6E 00 0F  00 D2 66 00   AF.A.T.i.n....f.
001004D0    6F 00 2E 00  74 00 78 00  74 00 00 00  00 00 FF FF   o...t.x.t.......
001004E0    46 41 54 49  4E 46 4F 20  54 58 54 20  00 64 B2 6C   FATINFO TXT .d.l
001004F0    5C 3D 5C 3D  00 00 B2 6C  5C 3D D6 03  35 01 00 00   \=\=...l\=..5...
00100500    41 66 00 69  00 6C 00 65  00 73 00 0F  00 79 00 00   Af.i.l.e.s...y..0.
---  fat32.img      --0x100400/0x4000000------------------------------------0.
```

Long-name Directory Entries

- You can ignore the long directory entries
  - Can just display the short names
  - This makes the project easier

Long-name Directory Entries

- How to know a directory entry is a long-name entry?
  - Byte 11: DIR_Attr
  - (ATTR_READ_ONLY | ATTR_HIDDEN | ATTR_SYSTEM | ATTR_VOLUME_ID) ➔ ATTR_LONG_NAME

(So, if all four of Read_only, Hidden, System and Volume_ID attributes are set, you know you have a long name entry.)

“Dot” Entries

- All directories (except root directory of entire system) have “.” and “..” directory entries
- “.” means “this directory”
- “..” means “the parent directory”
- Why do you think the root directory does not have these entries?

Sub-directories

- ATTR_Directory flag is set in the directory entry
- Treated just like a file in terms of cluster allocation
- Clusters contain 32 bytes directory entries, for the files and directories under this directory

Utility Operations

FAT32 Utility Oprations

Utility recognizes the following built-in commands:

- open
- close
- create
- rm
- size
- cd
- ls
- mkdir
- rmdir
- read
- write

A Few Definitions

- ***Read-Only Operations* –**can be completed without modifying file system image
- ***Write Operations* –** must modify file system image to complete

- *Hint:* Do the read-only operations first since they should not corrupt your image

FAT32 Utility Operations Classified

Read-Only

- open
- close
- ls
- size
- cd
- read

Write

- create
- rm**
- mkdir
- rmdir**
- write

***Will go over rm and rmdir next week*

Read-Only Operations

Read-Only Precautions

- File or directory must ***exist*** before performing operations on it
- File must be ***open*** and flagged for reading before you attempt to read from it
- Be sure you are reading from the right location
  - Off by 1 byte can throw the whole project off

Read-Only Operation: `open`

1. Check if the file is already open
2. Check that the mode-specifiers are valid (r, w, rw, or wr)
3. Check that the provided file name exists in the requested directory
4. If it exists, add the file to your open file table (or some similar data structure) with mode-specifiers

`open` Use Cases

- Successful open

```
/] open FATINFO.TXT rw
/]
```

- Unsuccessful open

```
/] open FATINFO.TXT rw
Error: file already open!
/]
```

open Use Cases

- Unsuccessful open

```
/] open NOTHERE.TXT rw
Error: file does not exist
/]
```

- Unsuccessful open

```
/] open DIRS rw
Error: cannot open a directory
/]
```

`open` Use Cases

- Unsuccessful open

```
/] open FATINFO.TXT z
Error: incorrect parameter
/]
```

Read-Only Operation: `close`

1. Check that the file name provided exists in your open file table (or the data structure you are using)
2. If it does, remove that entry from your open file table

`close` Use Cases

- Successful close

```
/] close FATINFO.TXT
/]
```

- Unsuccessful close

```
/] close NOTHERE.TXT
Error: file not open
/]
```

Read-Only Operation: `ls`

1. Make sure that provided directory name is valid
2. Seek first data cluster
3. Iterate through and print each directory entry in the cluster
4. If more directory entries left than first cluster can hold, seek next cluster and repeat 3

ls Use Cases

- Successful ls

```
/DIRS/] ls .
.    ..   A    B    C    D
/DIRS/]
```

Read-Only Operation: `size`

1. Check that provided file name exists in the requested directory
   - Can be accomplished by seeking through the clusters of the requested directory
2. If it does, extract the size information
   - Pay attention to endianness!

`size` Use Cases

- Successful size

```
/FILES/] size CONST.TXT
45119
/FILES/]
```

- Unsuccessful size

```
/FILES/] size NOTHERE.TXT
Error: file does not exist
/FILES/]
```

Read-Only Operation: cd

1. Check that provided directory name is a directory and it exists
2. Alter your current working directory to reflect the change
   - For ease of debugging and use, you may want to alter your prompt to show current working directory

cd Use Cases

- Successful cd

```
/] cd FILES
/FILES/]
```

- Unsuccessful cd

```
/] cd FATINFO.TXT
Error: not a directory
/]
```

cd Use Cases

- Unsuccessful cd

```
/] cd NOTHERE
Error: does not exist
/]
```

Read-Only Operation: `read`

1. Make sure file name provided is in open-file table and flagged as read-capable
2. Check that the provided position is valid
3. Check that the requested number of bytes is valid
4. Seek to data cluster corresponding to the requested start position and begin reading
5. If more data to be read, seek the next clusters and repeat 4

`read` Use Cases

- Successful read

```
/FILES/] read CONST.TXT 0 15
Provided by USC
/FILES/]
```

Data read from the file

- Unsuccessful read

```
/FILES/] read EMPTY.TXT 45 99
Error: attempt to read beyond EoF
/FILES/]
```

Write Operations

Write Precautions

- File must be ***open*** and flagged for writing before you attempt to write to it
- Make sure the supplied filename is not actually a directory before you try to write to it
- Check how much space is left in a cluster when writing a new string
  - Don’t want to overwrite other pre-existing data

Write Operations

- Many write operations may involve allocating a new cluster

Allocating a New Cluster

1. Search the FAT table for any free clusters
   - If none, return an out of space error!
2. Set the previous cluster to point to the new cluster number
   - Watch out, there may be more than one FAT to update
3. Set the new cluster to EoC (end of cluster chain)

Write Operations

- Many write operations involve creating a new directory entry

Creating a New Directory Entry

- Just create a short-name directory entry
  - All new directory nams will be of length 8 characters or less

Write Operation: `write`

1. Check that the parameters passed are valid (as for the read operation)
2. Seek the data cluster position requested by the operation
3. Write as much data as you can fit starting at the requested position up until the end of a given cluster
4. If a cluster fills up, allocate a new cluster
5. Repeat 3-4 until the write is complete

`write` Use Cases

- Successful write

```
/FILES/] open EMPTY.TXT rw
/FILES/] write EMPTY.TXT 0 10 "Not empty!"
/FILES/]
```

- Unsuccessful write

```
/FILES/] open EMPTY.TXT r
/FILES/] write EMPTY.TXT 0 10 "Not empty!"
Error: File is not open for writing
/FILES/]
```

`write` Use Cases

- Unsuccessful write

```
/FILES/] write EMPTY.TXT 0 10 “Not empty!”
Error: File not found
/FILES/]
```

Write Operation: `create`

1. Make sure the requested file name does NOT already exist in the requested location
2. Create new directory entry for the file
   - If there is enough room in the current cluster, write it there
   - If there is not enough space left in the cluster, allocate a new cluster and write it in the new cluster

`create` Use Cases

- Successful create

```
/FILES/] create HELLO.TXT
/FILES/] ls
. .. CONST.TXT EMPTY.TXT HELLO.TXT
/FILES/]
```

- Unsuccessful create

```
/FILES/] create EMPTY.TXT
Error: File already exists
/FILES/]
```

Write Operation: `mkdir`

- Similar to `create`, except give the directory entry the proper directory attribute

mkdir Use Cases

- Successful mkdir

```
/DIRS/] mkdir NEW
/DIRS/] ls
.    ..    NEW    A    B    C    D
/DIRS/]
```

`mkdir` Use Cases

- Unsuccessful mkdir

```
/DIRS/] mkdir A
Error: directory already exists
/DIRS/]
```

Next Week

- Operations rm and rmdir
- Answering any more questions