

1. a) 1) 4 - inode blocks. 1 for the file c, and 3 for the directories /, a, b
 - 2) 3 - directory blocks - one for root /, one for a, the other for b
 - 3) 1 - single indirect block as far as we know. The file definitely has more than 12 blocks (# of data blocks pointed by direct pointers), but less than 1036 (# of data blocks pointed by direct pointers and single indirect pointers). We are reading block 1034.
 - 4) 1 - data block for file c
- b) All of the above

Notes

- **Inode**



- Is short form of **index node**
- Describes a file system object such as file or data
- Contains all information about a file/directory, including
 - * File Type,
 - * Size
 - * Number of blocks allocated to it
 - * Protection information
 - * Time information (e.g time created, time modified)
 - * Location of data blocks residing on disk

References

- 1) Wikipedia, Inode, link
- 2) Machanick, Philip. (2016). Teaching Operating Systems: Just Enough Abstraction. 642. 10.1007/978-3-319-47680-3_10., link

- c) Size, the location of data blocks that reside on disk

Notes

- I wonder what information about blocks inode has. Is it total number of blocks both inode and data, or just data?
- I struggled a bit on this one. I should find an easier way to remember which information inode has

d) Rough Work

• **Creash Scenarios**

- When only new data block is written to disk
 - * This is fine in system's point of view
 - * No inode points to it (it doesn't contain any information about file)
 - * No bitmap points to it
 - * Is as if write never occurred
- When only the updated inode is written to disk
 - * There is no bitmap that's pointing to it
 - * There is new inode where existing inode is
 - * The data block Db hasn't been created
 - * Reading data where Db is will return garbage data
 - * there is a term for this. Is called **File-System inconsistency**
- When only inode bitmap is written to disk
 - * inode block pointed by bitmap is assumed to be allocated
 - * But there is no desired inode where it's pointing
 - * This is another example of **File-System-Inconsistency**
 - * If left as is, then space cannot be used for future use (**inode leak**)
- When only data bitmap is written to disk
 - * data block pointed by bitmap is assumed to be allocated
 - * But there is no desired inode where it's pointing
 - * This is another example of **File-System-Inconsistency**
 - * If left as is, then space cannot be used for future use (**data leak**)

Notes

- I wonder how system call for reading file/directory works in UNIX. Does it check for bitmap?
- I wonder how system call for deleting file/directory works in UNIX
- I wonder how system call for creatubg file/directory works in UNIX
- **File API**
 - open (create)

* Is a system call

* **Syntax:**

```
int fd = open("foo", O_CREAT|O_WRONLY|O_TRUNC, S_IRUSR|S_IWUSR)
```

- O_CREAT - Creates file "foo" if does not exist
- O_WRONLY - Open file for writing only (default)
- O_TRUNC - Overwrites existing file **Need example/Clarification**
- Can have multiple flags

* Returns **file descriptor** or fd for short

- Is an integer
- Is used to access a file
- Is private per process
- Can be used to read() and write() files

Example

```
#include <fcntl.h>
...
int fd;
mode_t mode = S_IRUSR | S_IWUSR | S_IRGRP | S_IROTH;
char *filename = "/tmp/file";
...
fd = open(filename, O_WRONLY | O_CREAT | O_TRUNC, mode);
...
```

File can be read by owner

File can also be written by owner

File can also be read by group

File can also be read by others

Means

1. File is Writable AND
2. Create file if doesn't exist AND
3. Overwrite file if exists

– (read)

* Is a system call

* **Syntax:**

```
ssize_t read (int fd, void *buf, size_t count)
```

- fd - file descriptor (from open())
- buf - container for the read data
- count - number of bytes to read

* Returns number of bytes read, if successful

- * Returns 0 if is at, or past the end of file

Example

```
char buf[4096];
int fd = open("/a/b/c", 0); // open in read-only mode
lseek(fd, 1034*4096, 0);    // seek to position (1034*4096) from start of file
read(fd, buf, 4096);        // read 4k of data from file
```

System Calls	Return Code	Current Offset
fd = open("file", O_RDONLY);	3	0
read(fd, buffer, 100);	100	100
read(fd, buffer, 100);	100	200
read(fd, buffer, 100);	100	300
read(fd, buffer, 100);	0	300
close(fd);	0	-

– write

- * Is a system call
- * Writes data out of a buffer
- * **Syntax:**

```
ssize_t write (int fd, const void * buf, size_t nbytes)
```

- fd - file descriptor
- buf - A pointer to a buffer to write to file
- nbytes - number of bytes to write. If smaller than buffer, the output is truncated

Example

```
#include <unistd.h>
#include <fcntl.h>

int main(void)
{
    int filedesc = open("testfile.txt", O_WRONLY | O_APPEND);

    if (filedesc < 0) {
        return -1;
    }

    if (write(filedesc, "This will be output to testfile.txt\n", 36) != 36) {
        write(2, "There was an error writing to testfile.txt\n", 43);
        return -1;
    }

    return 0;
}
```

– lseek

* Reads or write to a specific offset within a file

* **Syntax:**

```
off_t lseek (int fd, off_t offset, int whence)
```

· fd - file descriptor

· offset - the offset of pointer within file (in bytes)

· whence - the method of offset

SEEK_SET - offset from the start of file (absolute)

SEEK_CUR - offset from current location + offset bytes (relative)

SEEK_END - offset from the end of file

* Returns offset amount (in bytes) from the beginning of file

* Returns -1 if error

Example

System Calls	Return Code	OFT[10] Current Offset	OFT[11] Current Offset
fd1 = open("file", O_RDONLY);	3	0	-
fd2 = open("file", O_RDONLY);	4	0	0
read(fd1, buffer1, 100);	100	100	0
read(fd2, buffer2, 100);	100	100	100
close(fd1);	0	-	100
close(fd2);	0	-	-

System Calls	Return Code	Current Offset
fd = open("file", O_RDONLY);	3	0
lseek(fd, 200, SEEK_SET);	200	200
read(fd, buffer, 50);	50	250
close(fd);	0	-

- Reading and Writing Files
- Reading and Writing Files
- Renaming Files
- Removing Files
- Making Directories
- Reading Directories
- Removing Directories
- Hard Links
- Symbolic Links