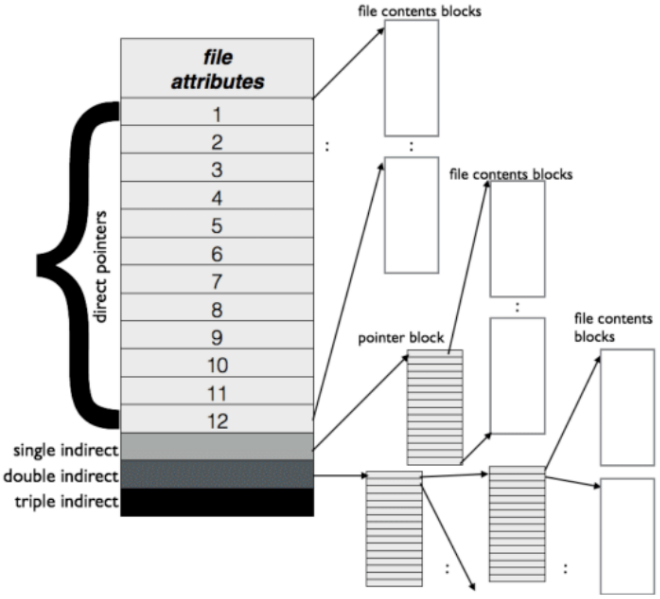
1. a) 1) 4 - inode blocks. 1 for the file `c`, and 3 for the directdories `/`, `a`, `b`
   2) 3 - directory blocks - one for root `/`, one for `a`, the other for `b`
   3) 1 - single indirect block as far as we know. The file definitely has more than 12 blocks (# of data blocks pointed by direct pounters), 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 occured
  - 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

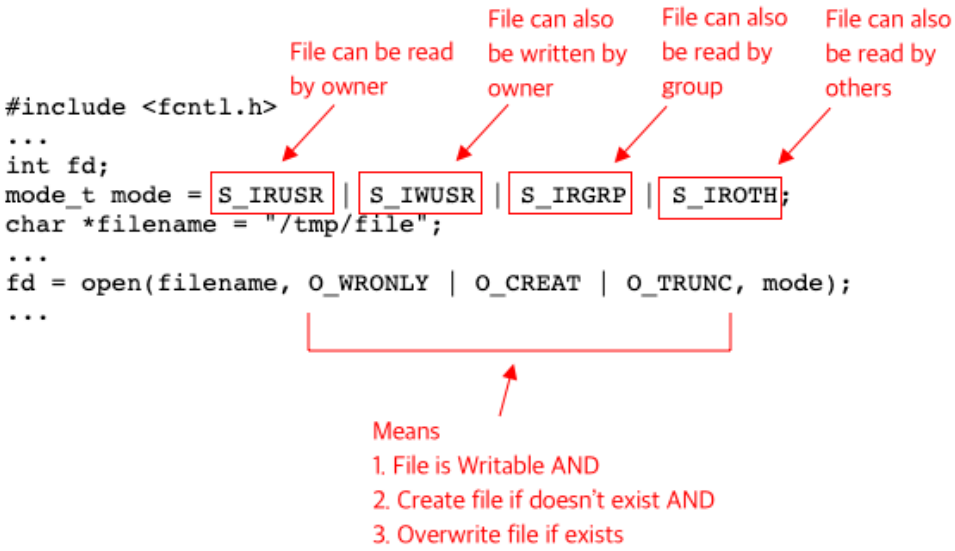
- I wonder how system call for reading file/directory works in UNIX. Does it check for bitmap?
- I wonder how system call for deleting file/directory works in UNIX
- I wonder how system call for creatubg file/directory works in UNIX
- **File API**
  - `open` (create)

* 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



– (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	–

read continues for each call

returns 0 if at end

– `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

```c
#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;
}
```

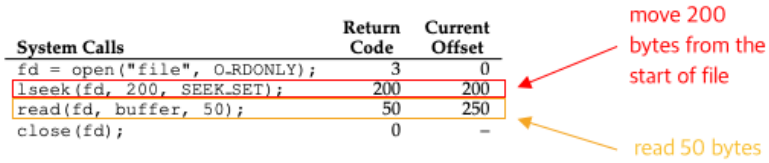
- `lseek`
  - Reads or write to a specific offset within a file
  - **Syntax:**

    ```
    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



- `rename`
  - Changes the name of file
  - **Syntax:** `int rename(const char *old, const char *new)`

    .

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