

CS/COE 1550 LAB 5

BIGGER FILES FOR XV6¹

In this lab you'll increase the maximum size of an xv6 file. Currently xv6 files are limited to 140 sectors (512 bytes each), or 71,680 bytes. This limit comes from the fact that an xv6 inode contains 12 "direct" block numbers and one "singly-indirect" block number, which refers to a block that holds up to 128 more block numbers, for a total of $12+128=140$. You'll change the xv6 file system code to support a "doubly-indirect" block in each inode, containing 128 addresses of singly-indirect blocks, each of which can contain up to 128 addresses of data blocks. The result will be that a file will be able to consist of up to 16523 sectors (or about 8.5 megabytes).

1. PRELIMINARIES

Modify your Makefile's `CPUS` definition so that it reads:

```
CPUS := 1
```

Add

```
QEMUEXTRA = -snapshot  
right before QEMUOPTS
```

The above two steps speed up qemu tremendously when xv6 creates large files.

`mkfs` initializes the file system to have fewer than 1000 free data blocks, too few to show off the changes you'll make. Modify `param.h` to set `FSSIZE` to:

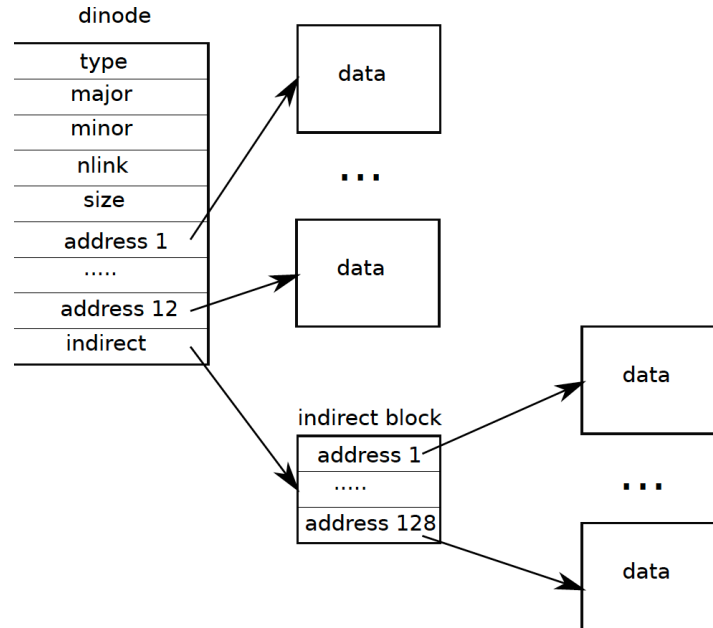
```
#define FSSIZE      20000 // size of file system in blocks
```

Copy the file `big.c` (on Canvas) into your xv6 directory, add it to the `UPROGS` list, start up xv6, and run `big`. It creates as big a file as xv6 will let it and reports the resulting size. It should say 140 sectors.

¹ Based on <https://pdos.csail.mit.edu/6.828/2017/homework/xv6-big-files.html>

2. WHAT TO LOOK AT

The format of an on-disk inode is defined by `struct dinode` in `fs.h`. You're particularly interested in `NDIRECT`, `NINDIRECT`, `MAXFILE`, and the `addrs[]` element of `struct dinode`. Below is a diagram of the standard xv6 inode.



The code that finds a file's data on disk is in `bmap()` in `fs.c`. Have a look at it and make sure you understand what it's doing. `bmap()` is called both when reading and writing a file. When writing, `bmap()` allocates new blocks as needed to hold file content, as well as allocating an indirect block if needed to hold block addresses.

`bmap()` deals with two kinds of block numbers. The `bn` argument is a "logical block" -- a block number relative to the start of the file. The block numbers in `ip->addrs[]`, and the argument to `bread()`, are disk block numbers. You can view `bmap()` as mapping a file's logical block numbers into disk block numbers.

3. YOUR JOB

Modify `bmap()` so that it implements a doubly-indirect block, in addition to direct blocks and a singly-indirect block. You'll have to have only 11 direct blocks, rather than 12, to make room for your new doubly-indirect block; you're not allowed to change the size of an on-disk inode. The first 11 elements of `ip->addrs[]` should be direct blocks; the 12th should be a singly-indirect

block (just like the current one); the 13th should be your new doubly-indirect block.

You don't have to modify xv6 to handle deletion of files with doubly-indirect blocks.

If all goes well, `big` will now report that it can write 16523 sectors. It will take `big` a few dozen seconds to finish.

4. HINTS

Make sure you understand `bmap()`. Write out a diagram of the relationships between `ip->addrs[]`, the indirect block, the doubly-indirect block and the singly-indirect blocks it points to, and data blocks. Make sure you understand why adding a doubly-indirect block increases the maximum file size by 16,384 blocks (really 16383, since you have to decrease the number of direct blocks by one).

Think about how you'll index the doubly-indirect block, and the indirect blocks it points to, with the logical block number.

If you change the definition of `NDIRECT`, you'll probably have to change the size of `addrs[]` in `struct inode` in `file.h`. Make sure that `struct inode` and `struct dinode` have the same number of elements in their `addrs[]` arrays.

If you change the definition of `NDIRECT`, make sure to create a new `fs.img`, since `mkfs` uses `NDIRECT` too to build the initial file systems. If you delete `fs.img`, `make` on Unix (not xv6) will build a new one for you.

If your file system gets into a bad state, perhaps by crashing, delete `fs.img` (do this from Unix, not xv6). `make` will build a new clean file system image for you.

Don't forget to `brelse()` each block that you `bread()`. `brelse()` releases the buffer cache for the block (check `bio.c`).

You should allocate indirect blocks and doubly-indirect blocks only as needed, like the original `bmap()`.

5. SUBMISSION INSTRUCTIONS

Submit to **GradeScope** the files that you have modified within the source code of xv6. You should modify the following files only:

- file.h
- fs.h
- param.h
- fs.c