Homework: bigger files for xv6

In this assignment you'll increase the maximum size of an xv6 file. Currently xv6 files are limited to 140 sectors, 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).

Submit your solution before the beginning of the next lecture to the submission web site.

Please collaborate with others on these exercises.

Preliminaries

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

```
CPUS := 1
```

And add `-snapshot` to the definition of `QEMUOPTS`:

```
QEMUOPTS = -hdb fs.img xv6.img -smp $(CPUS) -m 512 $(QEMUEXTRA) -snapshot
```

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 the code at the start of `mkfs.c` to read:

```
int nblocks = 21049;
int nlog = LOGSIZE;
int ninodes = 200;
int size = 21113
```

Download big.c 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.

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`. Look here for 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.

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.

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 your file system gets into a bad state, perhaps by crashing, you may need to delete `fs.img` (do this from Unix, not xv6).

Don't forget to `brelse()` each block that you `bread()`.

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

Submit: your modified fs.c