- [x] 1. Last time
- [x] 2. Directories
- [x] 3. Performance

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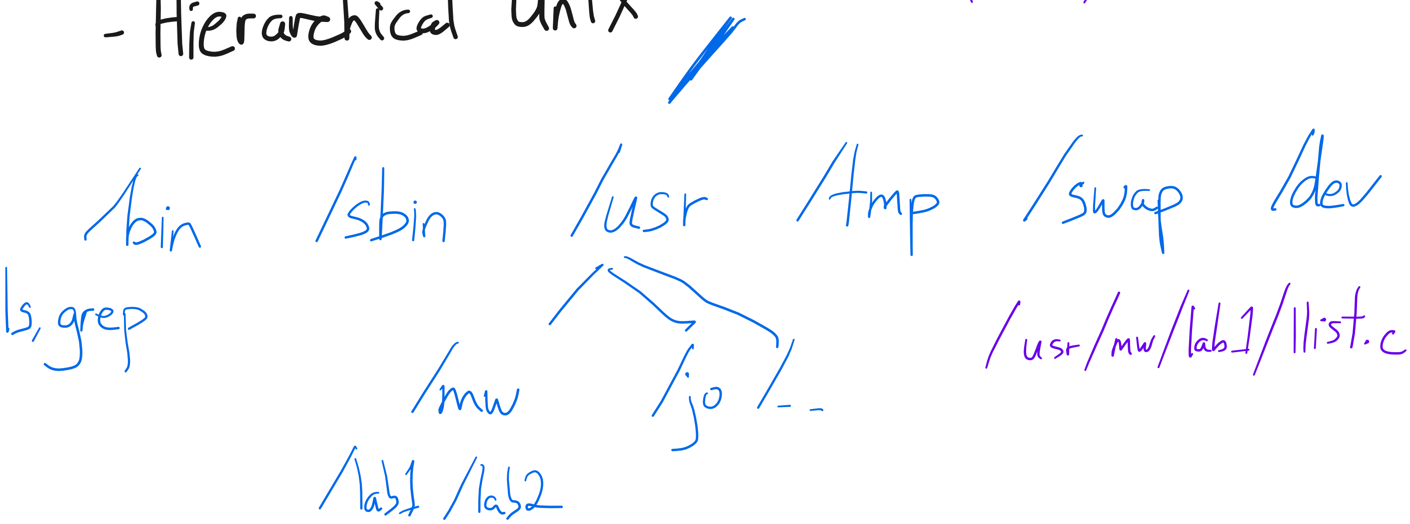
2. Directories

(see sheet at the end)

· Intro to directories

- Hierarchical Unix

$ cd /



Directory is a special kind of file:

struct dirent

name	inode #
bin	1021
dev	1001
sbin	2011
⋮	

← can be another directory. This turns the FS into a hierarchical tree.

This data (the table) can either live in the data blocks of a file (as in lab 5) or else in the inode of the directory (as in many of the examples that we will go over).

bootstrapping: root dir (/) always inode #2

special names: /, ., ..

can navigate the name space with:

$ cd name

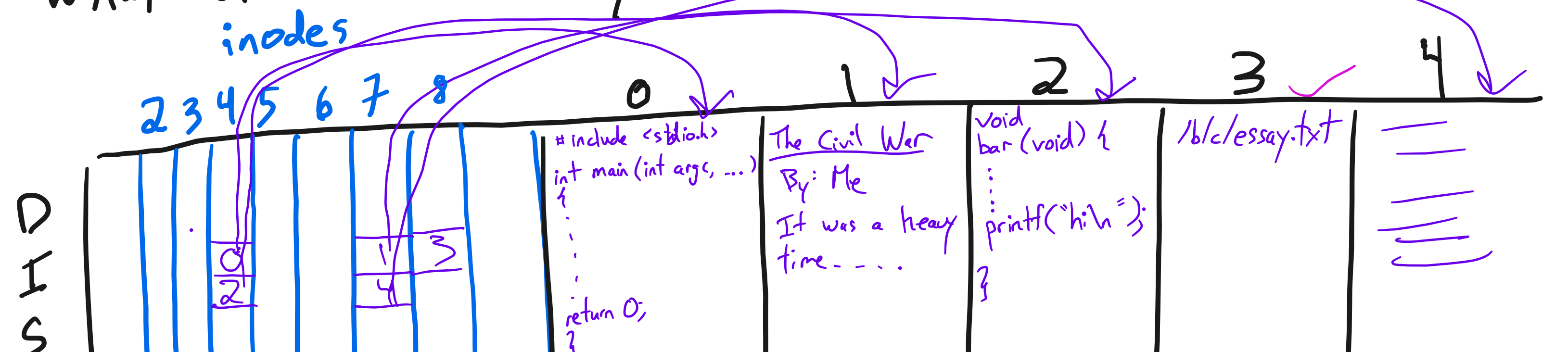
$ ls

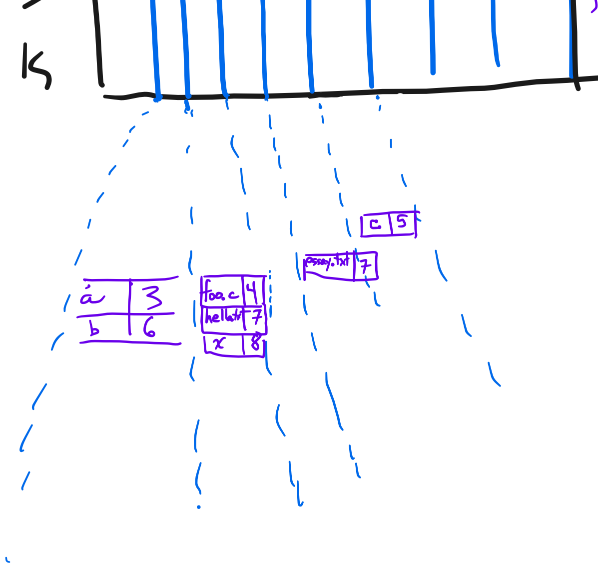
Example: two files

/a/foo.c

/b/c/essay.txt

what does the file system look like?





links: (see also below)

/a/hello.txt ≡ /b/c/essay.txt

unlink();

hard link:

$ ln /b/c/essay.txt /a/hello.txt

$ ln -s /b/c/essay.txt /a/x

soft link:

Links

Hard: $ ln x y   creates a synonym ("y") for ("x")

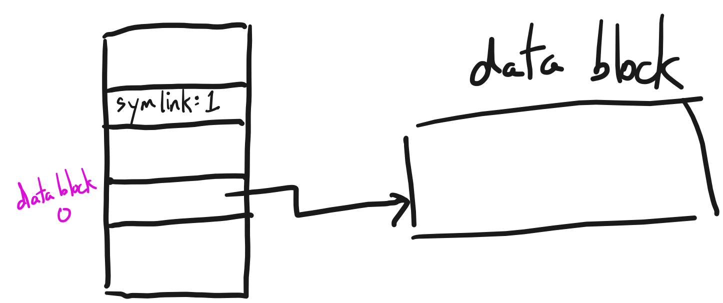
Question: what is the result of:

$ ln /b/c/essay.txt /a/hello.txt

?

Soft: $ ln -s x y

creates new inode. new file named "y". Its contents are "x".



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3. Performance

case study: FFS (1984)

problems w/ the original:

- blocks too small (512B)
- inode array at the begining of the disk
- free blocks stored in linked list on disk
- poor clustering of related objects

consecutive file blocks
inodes relative to pointed-to disk blocks
inodes for a given directory

result:

ls -l
grep <patt> *.c } ⇒ slow

Improvements?

- Make data blocks/inodes close to each other

- Cluster files in the same directory

- make data blocks bigger (4KB, 8KB, 16KB)

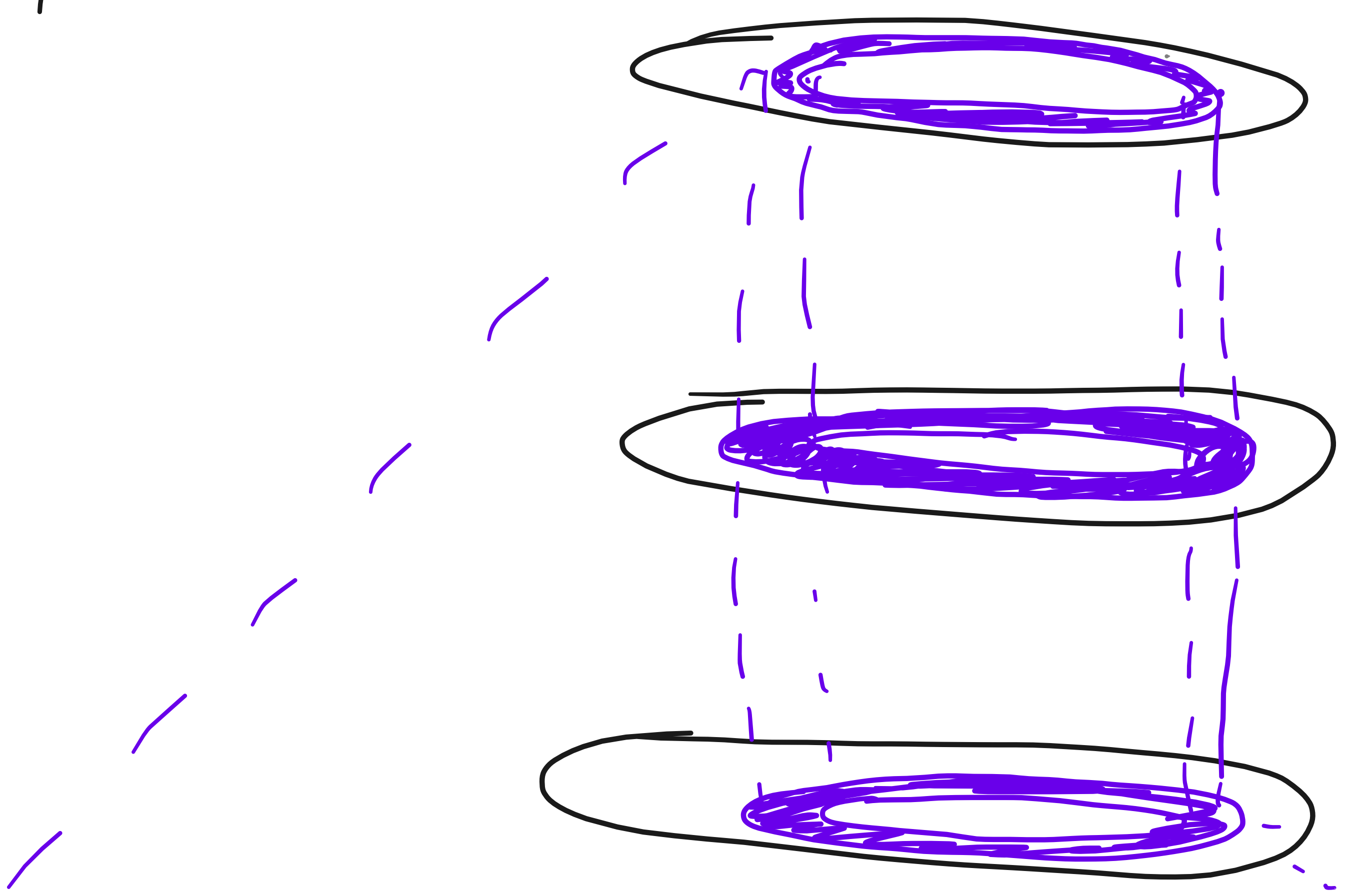
- free blocks: store separately (bitmap)

Assume 2TB disk, 4KB disk blocks
How much space does the bitmap take up?

$$\frac{2^{41} \text{ bytes}}{\text{disk } \sout{\text{file}} \text{ system}} \times \frac{1 \text{ block}}{2^{12} \text{ bytes}} \times \frac{1 \text{ bit}}{\text{block}} \times \frac{1 \text{ byte}}{8 \text{ bits}}$$

$$2^{41}/2^{15} = 2^{26} \text{ bytes} = \boxed{64 \text{ MB}}$$

- reserve space (lie to the user about free space)
- symbolic links
- atomic " rename " ($ mv abc.txt def.txt)
- cylinder groups (for clustering)



[superblock | bookkeeping | inodes | bitmap | data blocks (512 bytes each)] attempt to: put inodes and their data blocks in the same cyl. group

attempt to: put inodes of files in the same dir in the same cyl group.

new directory: place in cyl. group w/ higher than avg. # of free inodes

as a file grows, after it crosses 40KB, spill to next cyl. group, and do likewise for every 1MB thereafter.

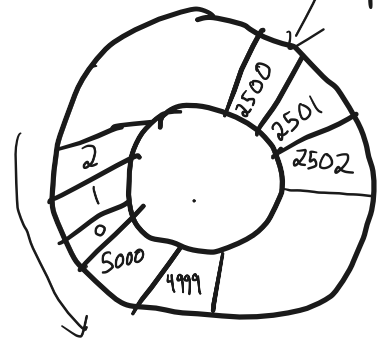
total perf:

20-40% of disk bandwidth for large files

10-20x improvement on the predecessor

Other things they did:

- buffer cache
- read entire track
- write in big chunks
- read ahead in big chunks (64KB)



can start reading in the middle of a track.

Directories

Approach 1: Single dir for whole system

map : <name, inumber>

mike-todo.txt, 64
sam-todo.txt, 121
⋮

Approach 2: Single dir for each user

Approach 3: Hierarchical name space

Directory maps from names to files **OR** other directories

File system then forms a tree or graph.

Large name spaces tend to be hierarchical

Ex: IP addresses, domain names

Cloud computing infrastructure has changed that! Google docs, for example.

www.cs.nyu.edu.

DNS

www.cs