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

---

## 2. Directories

(see sheet at the end)

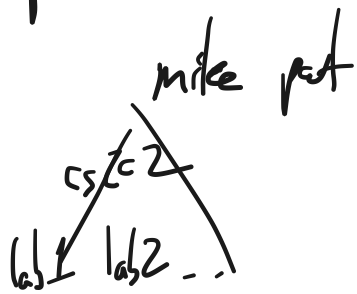
- Intro to directories
- Hierarchical Unix

/usr/mike/cs202/lab2/...

/

bin dev sbin tmp usr

ls grep




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

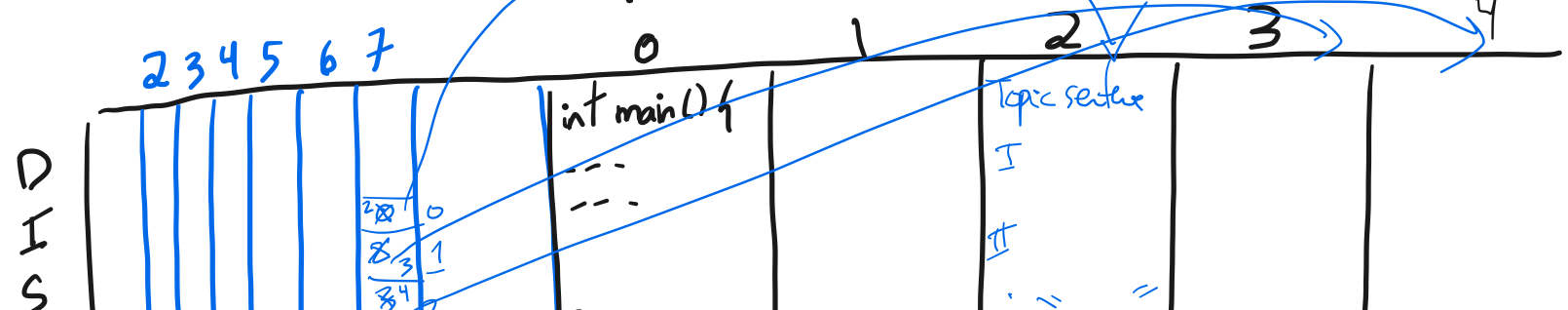
---

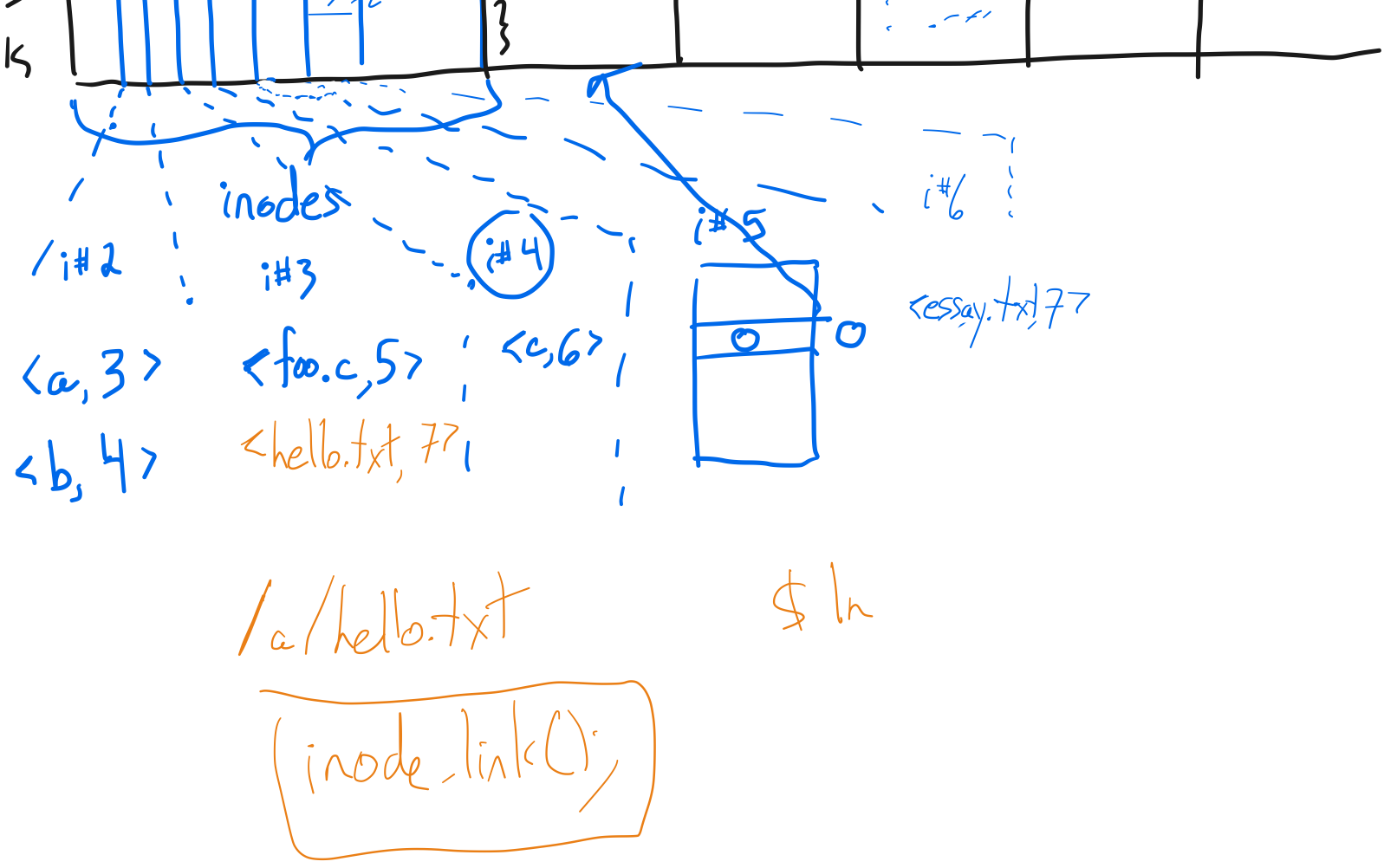
Example: two files

/a/foo.c

/b/c/essay.txt

what does the file system look like?






/a/hello.txt

inode_link();

$ ln

## Links

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

Question: what is the result of:

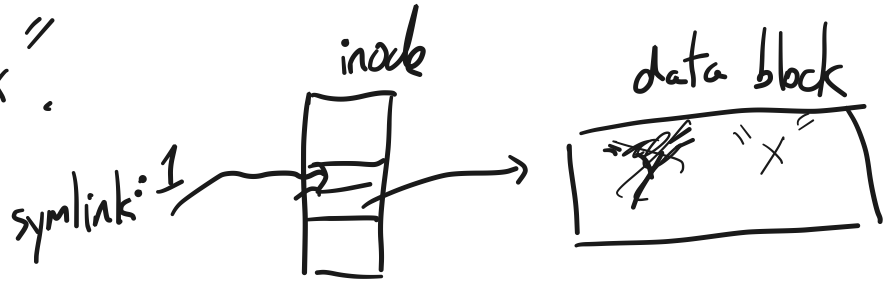
$ ln /b/c/essay.txt /a/hello.txt

?

unlink();

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 beginning 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 $ls -l

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, 16 KB)

- free blocks: store separately (bitmap)

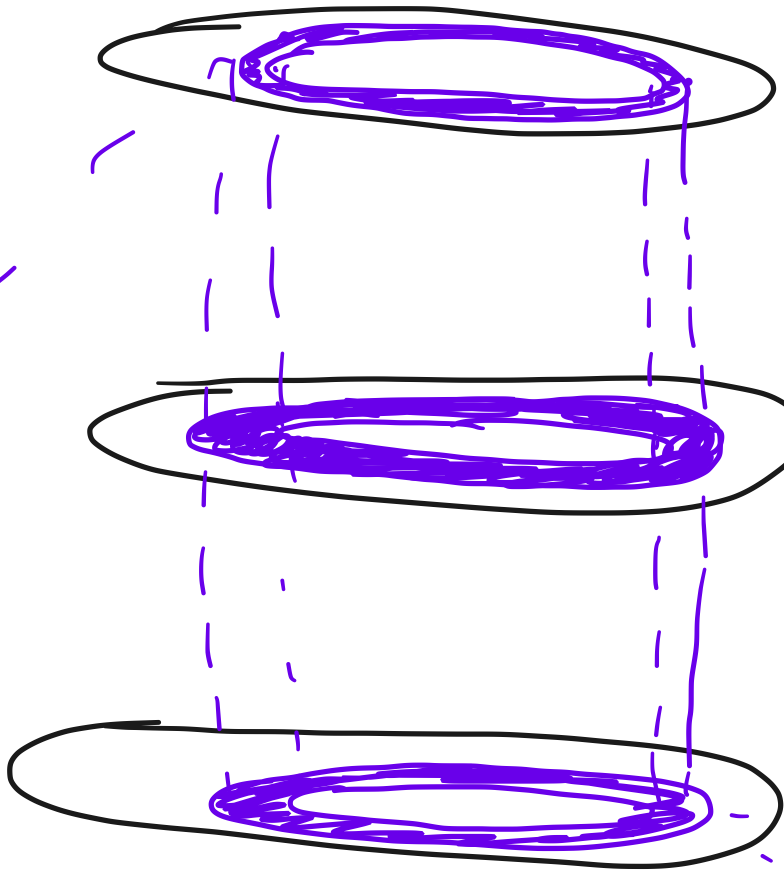
500 GB disk

4 KB disk blocks

128,000,000 disk blocks or entries, one bit per entry

16 MB

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



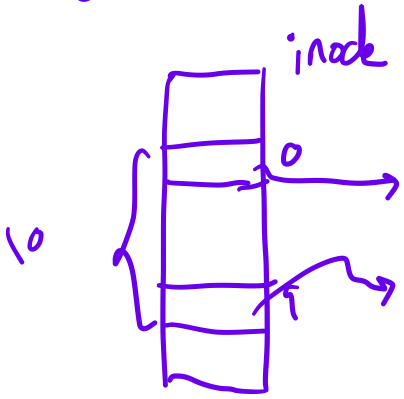
[ superblock | bookkeeping | inodes | bitmap | data blocks (512 bytes each) ]

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.



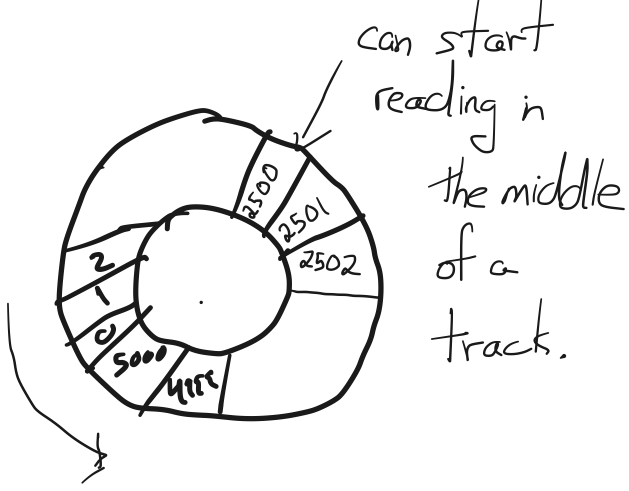

total perf:

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)



# Directories

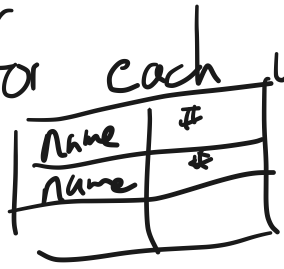
## Approach 1: Single dir for whole system

map : <name, inumber>

mike-todo.txt, 64
pat-todo.txt, 121
.
.
.
}

## Approach 2: Single dir for each user

/mike
/pat
/jo




ls

## 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