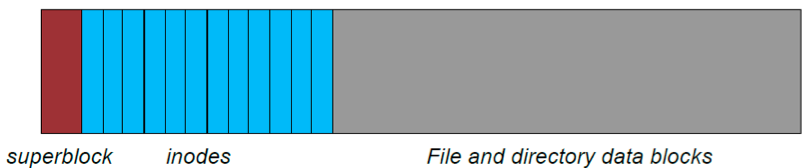
CS241#28 – inodes, permissions, modern fs

Reminder: Model disk layout for an ext2 filesystem. Inodes on disk have pointers to ~10 direct disk block entries, one indirect, one double indirect, one triple indirect block.



For ext2 with 4KB blocks and 32 bit addressing. What is the maximum supported disk size in bytes?

Each inode entry is 128 bytes and during formatting 64KB is reserved for inode array. How many files and directories can you create?

For ext2 filesystem with 4KB blocks and 32 bit addressing , how large can a file be before a triple indirect block is required?

Big idea: Forget names of files: *The 'inode'* ***is*** *the file.*

**What does the following do?**

char mystery[PATH\_MAX+1];

if (getcwd(mystery,PATH\_MAX)) puts(mystery);?

**How do we implement a directory? (spot the mistake)**

DIR\* dirp = **opendir**(".");

while ((dp = **readdir**(dirp)) != NULL) {

puts(dp->d\_name);

if (!strcmp(dp->d\_name, name)) {

return 1; /\* Found \*/

}

}

**closedir**(dirp);

return 0; /\* Not Found \*/

How can I find the inode number of a file?

How do I find out meta- file information?

int stat(const char \*path, struct stat \*buf);

int fstat(int fd, struct stat \*buf);

int lstat(const char \*path, struct stat \*buf);

struct stat {

dev\_t st\_dev; ID of device containing file

ino\_t st\_ino; inode number

mode\_t st\_mode; protection & other info

nlink\_t st\_nlink; number of hard links

uid\_t st\_uid; user ID of owner

gid\_t st\_gid; group ID of owner

dev\_t st\_rdev; device ID (if special file)

off\_t st\_size; total size, in bytes

blksize\_t st\_blksize; blocksize for file system

blkcnt\_t st\_blocks; number of 512B blocks allocated

time\_t st\_atime; time of last access

time\_t st\_mtime; time of last modification

time\_t st\_ctime; time of last status change

};

Users are integers!?

st\_mtime vs st\_ctime?

mymake.c ; compile iff source code is newer or target does not exist?

int s\_ok = stat("prog.c", &src);

int t\_ok = stat("a.out", &tgt);

double delta = difftime( \_\_\_\_\_\_\_\_, \_\_\_\_\_\_\_\_\_\_)

// -ve if t1 before t2

if(\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_) {

puts("Compiling");

system("gcc prog.c"); // = fork, exec shell, wait

} else { puts("nothing to do"); }

Does the inode contain the filename [101010 points]?

How can I have the same file appear in two different places in my file system?

(From code? Command?)

Reference counting?

rm = unlinking?

Changing File Permisssions?

chmod 644 /bin/sandwhich

chmod 755 /bin/sandwhich

chmod ugo-w /bin/sandwhich

chmod o-rx /bin/sandwhich

From code ... chmod(const char \*path, mode\_t mode);

What are the two "set uid bits" ?

set-user-ID-on-execution/set-group-ID-on-execution

Why are they useful? What common linux program uses this feature?

ext3: Journaling. Able to rollback to a known good state.

ext4: Performance. Encryption. Better limits (e.g. #files per dir)

Case study: ext4 has the "delayed data-write problem"

fd=open("file", O\_TRUNC); write(fd, data); close(fd);

fd=open("file.tmp");

write(fd, data);

close(fd);

rename("file.tmp", "file"); // Very happy in ext3

// but upgrading to ext4 : the rename could be completed before content is written to disk surface!

**ZFS**

1.1 Data integrity

1.2 RAID

1.3 Storage pools

1.4 ZFS cache: ARC (L1), L2ARC, ZIL

1.5 Gigantic Capacity (128bit model)

1.6 Copy-on-write transactional model

1.7 Snapshots and clones

1.8 Sending and receiving snapshots

1.9 Dynamic striping

1.10 Variable block sizes

1.11 Lightweight filesystem creation

1.12 Cache management

1.13 Adaptive endianness

1.14 Deduplication

1.15 Encryption

**BtrFS**

Extent based file storage

2^64 byte == 16 EiB maximum file size (practical limit is 8 EiB due to Linux VFS)

Space-efficient packing of small files

Space-efficient indexed directories

Dynamic inode allocation

Writable snapshots, read-only snapshots

Subvolumes (separate internal filesystem roots)

Checksums on data and metadata (crc32c)

Compression (zlib and LZO)

Integrated multiple device support

File Striping, File Mirroring, File Striping+Mirroring, Striping with Single and Dual Parity implementations

SSD (Flash storage) awareness (TRIM/Discard for reporting free blocks for reuse) and optimizations

Efficient Incremental Backup

Background scrub process for finding and fixing errors on files with redundant copies

Online filesystem defragmentation

Offline filesystem check

In-place conversion of existing ext3/4 file systems

Seed devices. Create a (readonly) filesystem that acts as a template to seed other Btrfs filesystems. The original filesystem and devices are included as a readonly starting point for the new filesystem. Using copy on write, all modifications are stored on different devices; the original is unchanged.

Subvolume-aware quota support

Send/receive of subvolume changes

Efficient incremental filesystem mirroring

Batch, or out-of-band deduplication (happens after writes, not during)