운영체제 lab3

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1. goal

- ramdisk에 파일시스템 ext2를 생성하여 mount한 후 디렉토리와 파일의 inode와 disk block을 찾는다.

- 커널 모듈을 사용해 mount 후 dmesg 사용 시 학번과 이름이 출력되도록 한다.

2. analysis results and snapshots

```
oslab@oslab-DKU:~/2021_DKU_OS/lab3_filesystem$ sudo mkfs.ext2 /dev/ramdisk
mke2fs 1.45.5 (07-Jan-2020)
Creating filesystem with 131072 4k blocks and 32768 inodes
Filesystem UUID: 075f002d-6e84-4d8e-8568-0ff789053522
Superblock backups stored on blocks:
        32768, 98304

Allocating group tables: done
Writing inode tables: done
Writing superblocks and filesystem accounting information: done

oslab@oslab-DKU:~/2021_DKU_OS/lab3_filesystem$ sudo mkdir mnt
oslab@oslab-DKU:~/2021_DKU_OS/lab3_filesystem$ sudo mount /dev/ramdisk ./mnt
oslab@oslab-DKU:~/2021_DKU_OS/lab3_filesystem$ s
s: command not found
oslab@oslab-DKU:~/2021_DKU_OS/lab3_filesystem$ ls
append.c    mnt             os_ext2     ramdisk.mod    ramdisk.o
create.sh   modules.order   ramdisk.c   ramdisk.mod.c
Makefile    Module.symvers  ramdisk.ko  ramdisk.mod.o
oslab@oslab-DKU:~/2021_DKU_OS/lab3_filesystem$ ls ./mnt
lost+found
oslab@oslab-DKU:~/2021_DKU_OS/lab3_filesystem$ ./create.sh
```

github에 제공된 명령어를 통해 초기 작업을 처리하였다.

mnt 폴더에 8번 디렉터리에서 54 파일을 찾을 수 있었다.

```
oslab@oslab-DKU:~/2021_DKU_OS/lab3_filesystem/mnt/8$ stat 54
  File: 54
  Size: 8199            Blocks: 24         IO Block: 4096   regular file
Device: fc00h/64512d    Inode: 8450        Links: 1
Access: (0644/-rw-r--r--)  Uid: (    0/    root)   Gid: (    0/    root)
Access: 2021-05-27 12:28:05.700936713 +0900
Modify: 2021-05-27 12:34:06.572006187 +0900
Change: 2021-05-27 12:34:06.572006187 +0900
```

총 24개의 블록을 사용하고 있으며, 아이노드의 id는 8450임을 알 수 있다.

```
root@oslab-DKU:/home/oslab/2021_DKU_OS/lab3_filesystem# ls
apd  append.c  create.sh  Makefile  mnt  modules.order  Module.symvers  os_ext2  ramdisk.c  ramdisk.ko  ramdisk.mod  ramdisk.mod.c  ramdisk.mod.o  ramdisk.o
root@oslab-DKU:/home/oslab/2021_DKU_OS/lab3_filesystem# ./apd mnt/8/54 13 8/54-13
root@oslab-DKU:/home/oslab/2021_DKU_OS/lab3_filesystem# ls -l mnt/8/54
-rw-r--r-- 1 root root 49160  5월 27 14:17 mnt/8/54
```

mnt/8/54 파일에 블록 하나를 추가하였다.

1) superblock analysis (group 0) => superblock의 내용은 중복되므로 여기서만 분석한다.

```
root@oslab-DKU:/home/oslab/2021_DKU_OS/lab3_filesystem# xxd -g 4 -l 0x100 -s 0x400 /dev/ramdisk
00000400: 00800000 00000200 99190000 8ff70100  ................
00000410: f57f0000 00000000 02000000 02000000  ................
00000420: 00800000 00800000 00200000 a410af60  ......... .....`
00000430: a410af60 0100ffff 53ef0000 01000000  ...`....S.......
00000440: 7510af60 00000000 00000000 01000000  u..`............
00000450: 00000000 0b000000 00010000 38000000  ............8...
00000460: 02000000 03000000 075f002d 6e844d8e  ........._.-n.M.
00000470: 85680ff7 89053522 00000000 00000000  .h....5"........
00000480: 00000000 00000000 2f686f6d 652f6f73  ......../home/os
00000490: 6c61622f 32303231 5f444b55 5f4f532f  lab/2021_DKU_OS/
000004a0: 6c616233 5f66696c 65737973 74656d2f  lab3_filesystem/
000004b0: 6d6e7400 00000000 00000000 00000000  mnt.............
000004c0: 00000000 00000000 00000000 00001f00  ................
000004d0: 00000000 00000000 00000000 00000000  ................
000004e0: 00000000 00000000 00000000 547f5557  ............T.UW
000004f0: 09ac45be bdc8086a 9fe3ea46 01000000  ..E....j._.F....
```

- inode count: 0x80

-block count: 0x20000

-log block size: 0x2

-blocks per group: 0x80

-inodes per group: 0x20

-block group number: 0x0

2) group descriptor table (group 0)

```
root@oslab-DKU:/home/oslab/2021_DKU_OS/lab3_filesystem# xxd -g 4 -l 0x100 -s 0x1000 /dev/ramdisk
00001000: 21000000 22000000 23000000 d77d2b1f  !..."...#....}+.
00001010: 04000400 00000000 00000000 00000000  ................
00001020: 21800000 22800000 23800000 dd7dd11e  !..."...#....}..
00001030: 03000400 00000000 00000000 00000000  ................
00001040: 00000100 01000100 02000100 3a72361f  ............:r6.
00001050: 02000400 00000000 00000000 00000000  ................
00001060: 21800100 22800100 23800100 dd7dd11e  !..."...#....}..
00001070: 03000400 00000000 00000000 00000000  ................
00001080: 00000000 00000000 00000000 00000000  ................
00001090: 00000000 00000000 00000000 00000000  ................
000010a0: 00000000 00000000 00000000 00000000  ................
000010b0: 00000000 00000000 00000000 00000000  ................
000010c0: 00000000 00000000 00000000 00000000  ................
000010d0: 00000000 00000000 00000000 00000000  ................
000010e0: 00000000 00000000 00000000 00000000  ................
000010f0: 00000000 00000000 00000000 00000000  ................
```

*group 0

-block bitmap: 0x21 블록부터 시작

-inode bitmap: 0x22 블록부터 시작

-inode table: 0x23 블록부터 시작

```
root@oslab-DKU:/home/oslab/2021_DKU_OS/lab3_filesystem# xxd -g 4 -l 0x100 -s 0x23100 /dev/ramdisk
00023100: ed410000 00100000 df11af60 c511af60  .A.........`...`
00023110: c511af60 00000000 00000d00 08000000  ...`............
00023120: 00000000 0a000000 23020000 00000000  ........#.......
00023130: 00000000 00000000 00000000 00000000  ................
00023140: 00000000 00000000 00000000 00000000  ................
00023150: 00000000 00000000 00000000 00000000  ................
00023160: 00000000 00000000 00000000 00000000  ................
00023170: 00000000 00000000 00000000 00000000  ................
00023180: 20000000 a41006a9 a41006a9 70d2638d   ...........p.c.
00023190: 7510af60 00000000 00000000 00000000  u..`............
000231a0: 00000000 00000000 00000000 00000000  ................
000231b0: 00000000 00000000 00000000 00000000  ................
000231c0: 00000000 00000000 00000000 00000000  ................
000231d0: 00000000 00000000 00000000 00000000  ................
000231e0: 00000000 00000000 00000000 00000000  ................
000231f0: 00000000 00000000 00000000 00000000  ................
root@oslab-DKU:/home/oslab/2021_DKU_OS/lab3_filesystem# xxd -g 4 -l 0x100 -s 0x223000 /dev/ramdisk
00223000: 02000000 0c000102 2e000000 02000000  ................
00223010: 0c000202 2e2e0000 0b000000 14000a02  ................
00223020: 6c6f7374 2b666f75 6e640000 01400000  lost+found...@..
00223030: 0c000102 30000000 01200000 0c000102  ....0.... ......
00223040: 31000000 01600000 0c000102 32000000  1....`......2...
00223050: 0c000000 0c000102 33000000 71000000  ........3...q...
00223060: 0c000102 34000000 66200000 0c000102  ....4...f ......
00223070: 35000000 66600000 0c000102 36000000  5...f`......6...
00223080: 66400000 0c000102 37000000 cb200000  f@......7.... ..
00223090: 0c000102 38000000 cb600000 680f0102  ....8....`..h...
002230a0: 39000000 00000000 00000000 00000000  9...............
002230b0: 00000000 00000000 00000000 00000000  ................
002230c0: 00000000 00000000 00000000 00000000  ................
002230d0: 00000000 00000000 00000000 00000000  ................
002230e0: 00000000 00000000 00000000 00000000  ................
002230f0: 00000000 00000000 00000000 00000000  ................
```

root inode를 찾았다.

```
root@oslab-DKU:/home/oslab/2021_DKU_OS/lab3_filesystem# xxd -g 4 -l 0x100 -s 0x23100 /dev/ramdisk
00023100: ed410000 00100000 df11af60 c511af60  .A.........`...`
00023110: c511af60 00000000 00000d00 08000000  ...`............
00023120: 00000000 0a000000 23020000 00000000  ........#.......
00023130: 00000000 00000000 00000000 00000000  ................
00023140: 00000000 00000000 00000000 00000000  ................
00023150: 00000000 00000000 00000000 00000000  ................
00023160: 00000000 00000000 00000000 00000000  ................
00023170: 00000000 00000000 00000000 00000000  ................
00023180: 20000000 a41006a9 a41006a9 70d2638d   ...........p.c.
00023190: 7510af60 00000000 00000000 00000000  u..`............
000231a0: 00000000 00000000 00000000 00000000  ................
000231b0: 00000000 00000000 00000000 00000000  ................
000231c0: 00000000 00000000 00000000 00000000  ................
000231d0: 00000000 00000000 00000000 00000000  ................
000231e0: 00000000 00000000 00000000 00000000  ................
000231f0: 00000000 00000000 00000000 00000000  ................
root@oslab-DKU:/home/oslab/2021_DKU_OS/lab3_filesystem# xxd -g 4 -l 0x100 -s 0x223000 /dev/ramdisk
00223000: 02000000 0c000102 2e000000 02000000  ................
00223010: 0c000202 2e2e0000 0b000000 14000a02  ................
00223020: 6c6f7374 2b666f75 6e640000 01400000  lost+found...@..
00223030: 0c000102 30000000 01200000 0c000102  ....0.... ......
00223040: 31000000 01600000 0c000102 32000000  1....`......2...
00223050: 0c000000 0c000102 33000000 71000000  ........3...q...
00223060: 0c000102 34000000 66200000 0c000102  ....4...f ......
00223070: 35000000 66600000 0c000102 36000000  5...f`......6...
00223080: 66400000 0c000102 37000000 cb200000  f@......7.... ..
00223090: 0c000102 38000000 cb600000 680f0102  ....8....`..h...
002230a0: 39000000 00000000 00000000 00000000  9...............
002230b0: 00000000 00000000 00000000 00000000  ................
002230c0: 00000000 00000000 00000000 00000000  ................
002230d0: 00000000 00000000 00000000 00000000  ................
002230e0: 00000000 00000000 00000000 00000000  ................
002230f0: 00000000 00000000 00000000 00000000  ................
```

8번 디렉토리의 file type은 0x2로 directory이고 inode number는 0x20cb = $8395_{(10)}$ 이다.

(8395-1) / 0x2000 = 1 … 202

첫 번째 block의 202번 inode이다.

위에서 mnt/8/54의 inode의 inumber는 8450임을 알았으므로

group = (8450-1)/8192 = **1 … 257**

따라서 54 파일의 inode는 1 block group의 **inode table의 257**번째에 위치한다.

3) 1 block group superblock

block size(0x1000) * block per group을 계산하면1 block group의 superblock이 있는 곳의 주소가 나온다.

0x1000 * 0x8000 = 0x8000000

```
root@oslab-DKU:/home/oslab/2021_DKU_OS/lab3_filesystem# xxd -g 4 -l 0x100 -s 0x8000000 /dev/ramdisk
08000000: 00800000 00000200 99190000 8ff70100  ................
08000010: f57f0000 00000000 02000000 02000000  ................
08000020: 00800000 00800000 00200000 00000000  ......... ......
08000030: 7510af60 0000ffff 53ef0000 01000000  u..`....S.......
08000040: 7510af60 00000000 00000000 01000000  u..`............
08000050: 00000000 0b000000 00010100 38000000  ............8...
08000060: 02000000 03000000 075f002d 6e844d8e  ........._.-n.M.
08000070: 85680ff7 89053522 00000000 00000000  .h....5"........
08000080: 00000000 00000000 00000000 00000000  ................
08000090: 00000000 00000000 00000000 00000000  ................
080000a0: 00000000 00000000 00000000 00000000  ................
080000b0: 00000000 00000000 00000000 00000000  ................
080000c0: 00000000 00000000 00000000 00001f00  ................
080000d0: 00000000 00000000 00000000 00000000  ................
080000e0: 00000000 00000000 00000000 547f5557  ............T.UW
080000f0: 09ac45be bdc8086a 9fe3ea46 01000000  ..E....j...F....
```

여기서 한 블럭(0x1000) 더 가면 1 block group의 group descriptor table이 나온다.

4) group descriptor table of 1 block group

```
root@oslab-DKU:/home/oslab/2021_DKU_OS/lab3_filesystem# xxd -g 4 -l 0x100 -s 0x8001000 /dev/ramdisk
08001000: 21000000 22000000 23000000 d77df51f  !..."...#....}..
08001010: 02000000 00000000 00000000 00000000  ................
08001020: 21800000 22800000 23800000 dd7d0020  !..."...#....}.
08001030: 00000000 00000000 00000000 00000000  ................
08001040: 00000100 01000100 02000100 fe7d0020  ............}.
08001050: 00000000 00000000 00000000 00000000  ................
08001060: 21800100 22800100 23800100 dd7d0020  !..."...#....}.
08001070: 00000000 00000000 00000000 00000000  ................
08001080: 00000000 00000000 00000000 00000000  ................
08001090: 00000000 00000000 00000000 00000000  ................
080010a0: 00000000 00000000 00000000 00000000  ................
080010b0: 00000000 00000000 00000000 00000000  ................
080010c0: 00000000 00000000 00000000 00000000  ................
080010d0: 00000000 00000000 00000000 00000000  ................
080010e0: 00000000 00000000 00000000 00000000  ................
080010f0: 00000000 00000000 00000000 00000000  ................
```

group 1

-block bitmap +0x21블록부터 시작

-inode bitmap +0x22 블록부터 시작

-inode table +0x23 블록부터 시작

5) inode table of 1 block group

directory 8 inode

0x8000000 + 0x23000 + 0x100 * 202 = 0x802fa00

```
root@oslab-DKU:/home/oslab/2021_DKU_OS/lab3_filesystem# xxd -g 4 -l 0x100 -s 0x802fa00 /dev/ramdisk
0802fa00: ed410000 00100000 332baf60 322baf60  .A......3+.`2+.`
0802fa10: 322baf60 00000000 00000200 08000000  2+.`............
0802fa20: 00000000 67000000 0a020100 00000000  ....g...........
0802fa30: 00000000 00000000 00000000 00000000  ................
0802fa40: 00000000 00000000 00000000 00000000  ................
0802fa50: 00000000 00000000 00000000 00000000  ................
0802fa60: 00000000 35de31cd 00000000 00000000  ....5.1.........
0802fa70: 00000000 00000000 00000000 00000000  ................
0802fa80: 20000000 e4396c62 e4396c62 048e0756   ....9lb.9lb...V
0802fa90: c511af60 645b41a4 00000000 00000000  ...`d[A.........
0802faa0: 00000000 00000000 00000000 00000000  ................
0802fab0: 00000000 00000000 00000000 00000000  ................
0802fac0: 00000000 00000000 00000000 00000000  ................
0802fad0: 00000000 00000000 00000000 00000000  ................
0802fae0: 00000000 00000000 00000000 00000000  ................
0802faf0: 00000000 00000000 00000000 00000000  ........_.......
```

8번 디렉토리에서 direct pointer의 주소인 1020a000에 들어가보면 파일들의 이름이 쭉 뜬다. 여기서 54 파일을 찾았다.

```
1020a270: fe200000 0c000201 35300000 ff200000  . ......50... ..
1020a280: 0c000201 35310000 00210000 0c000201  ....51...!......
1020a290: 35320000 01210000 0c000201 35330000  52...!......53..
1020a2a0: 02210000 0c000201 35340000 03210000  .!......54...!..
1020a2b0: 0c000201 35350000 04210000 0c000201  ....55...!......
1020a2c0: 35360000 05210000 0c000201 35370000  56...!......57..
1020a2d0: 06210000 0c000201 35380000 07210000  .!......58...!..
1020a2e0: 0c000201 35390000 08210000 0c000201  ....59...!......
1020a2f0: 36300000 09210000 0c000201 36310000  60...!......61..
1020a300: 0a210000 0c000201 36320000 0b210000  .!......62...!..
1020a310: 0c000201 36330000 0c210000 0c000201  ....63...!......
1020a320: 36340000 0d210000 0c000201 36350000  64...!......65..
1020a330: 0e210000 0c000201 36360000 0f210000  .!......66...!..
1020a340: 0c000201 36370000 10210000 0c000201  ....67...!......
1020a350: 36380000 11210000 0c000201 36390000  68...!......69..
```

54파일의 file type은 01로 regular file이다.

이 파일의 아이넘버는 0x2102 = 8450이다. (stat mnt/8/54로 본 내용과 동일하다.)

257번째에 존재하므로

0x8000000 + 0x23000 + 0x100 * 257 = 0x8023000 + 0x10b00 = **0x8033100**

```
root@oslab-DKU:/home/oslab/2021_DKU_OS/lab3_filesystem# xxd -g 4 -l 0x100 -s 0x8033100 /dev/ramdisk
08033100: a4810000 08c00000 c511af60 562baf60  ...........`V+.`
08033110: 562baf60 00000000 00000100 28000000  V+.`........(...
08033120: 00000000 01000000 0f050100 17080100  ................
08033130: 7b080100 00000000 00000000 00000000  {...............
08033140: 00000000 00000000 00000000 00000000  ................
08033150: 00000000 00000000 71090100 00000000  ........q.......
08033160: 00000000 7892890f 00000000 00000000  ....x...........
08033170: 00000000 00000000 00000000 00000000  ................
08033180: 20000000 002369cd 002369cd 24c81da7   ....#i..#i.$...
08033190: c511af60 24c81da7 00000000 00000000  ...`$...........
080331a0: 00000000 00000000 00000000 00000000  ................
080331b0: 00000000 00000000 00000000 00000000  ................
080331c0: 00000000 00000000 00000000 00000000  ................
080331d0: 00000000 00000000 00000000 00000000  ................
080331e0: 00000000 00000000 00000000 00000000  ................
080331f0: 00000000 00000000 00000000 00000000  ................
```

0x1050f000

```
root@oslab-DKU:/home/oslab/2021_DKU_OS/lab3_filesystem# xxd -g 4 -l 0x100 -s 0x1050f000 /dev/ramdisk
1050f000: 382f3534 2d310a00 00000000 00000000  8/54-1..........
1050f010: 00000000 00000000 00000000 00000000  ................
1050f020: 00000000 00000000 00000000 00000000  ................
1050f030: 00000000 00000000 00000000 00000000  ................
1050f040: 00000000 00000000 00000000 00000000  ................
1050f050: 00000000 00000000 00000000 00000000  ................
1050f060: 00000000 00000000 00000000 00000000  ................
1050f070: 00000000 00000000 00000000 00000000  ................
1050f080: 00000000 00000000 00000000 00000000  ................
1050f090: 00000000 00000000 00000000 00000000  ................
1050f0a0: 00000000 00000000 00000000 00000000  ................
1050f0b0: 00000000 00000000 00000000 00000000  ................
1050f0c0: 00000000 00000000 00000000 00000000  ................
1050f0d0: 00000000 00000000 00000000 00000000  ................
1050f0e0: 00000000 00000000 00000000 00000000  ................
1050f0f0: 00000000 00000000 00000000 00000000  ................
```

8/54-1 데이터가 8byte로 저장 돼 있다.

0x10817000

```
root@oslab-DKU:/home/oslab/2021_DKU_OS/lab3_filesystem# xxd -g 4 -l 0x100 -s 0x10817000 /dev/ramdisk
10817000: 382f3534 2d320a00 00000000 00000000  8/54-2..........
10817010: 00000000 00000000 00000000 00000000  ................
10817020: 00000000 00000000 00000000 00000000  ................
10817030: 00000000 00000000 00000000 00000000  ................
10817040: 00000000 00000000 00000000 00000000  ................
10817050: 00000000 00000000 00000000 00000000  ................
10817060: 00000000 00000000 00000000 00000000  ................
10817070: 00000000 00000000 00000000 00000000  ................
10817080: 00000000 00000000 00000000 00000000  ................
10817090: 00000000 00000000 00000000 00000000  ................
108170a0: 00000000 00000000 00000000 00000000  ................
108170b0: 00000000 00000000 00000000 00000000  ................
108170c0: 00000000 00000000 00000000 00000000  ................
108170d0: 00000000 00000000 00000000 00000000  ................
108170e0: 00000000 00000000 00000000 00000000  ................
```

0x1087b000

```
root@oslab-DKU:/home/oslab/2021_DKU_OS/lab3_filesystem# xxd -g 4 -l 0x100 -s 0x1087b000 /dev/ramdisk
1087b000: 382f3534 2d330a00 00000000 00000000  8/54-3.........
1087b010: 00000000 00000000 00000000 00000000  ................
1087b020: 00000000 00000000 00000000 00000000  ................
1087b030: 00000000 00000000 00000000 00000000  ................
1087b040: 00000000 00000000 00000000 00000000  ................
1087b050: 00000000 00000000 00000000 00000000  ................
1087b060: 00000000 00000000 00000000 00000000  ................
1087b070: 00000000 00000000 00000000 00000000  ................
1087b080: 00000000 00000000 00000000 00000000  ................
1087b090: 00000000 00000000 00000000 00000000  ................
1087b0a0: 00000000 00000000 00000000 00000000  ................
1087b0b0: 00000000 00000000 00000000 00000000  ................
1087b0c0: 00000000 00000000 00000000 00000000  ................
1087b0d0: 00000000 00000000 00000000 00000000  ................
1087b0e0: 00000000 00000000 00000000 00000000  ................
1087b0f0: 00000000 00000000 00000000 00000000  ................
```

블록 4개 중 3개만 저장 돼 있어서 나머지 하나를 찾으려고 indirect pointer 영역도 살펴보았다.

```
root@oslab-DKU:/home/oslab/2021_DKU_OS/lab3_filesystem# xxd -g 4 -l 0x100 -s 0x8033100 /dev/ramdisk
08033100: a4810000 08c00000 c511af60 562baf60  ...........`V+.`
08033110: 562baf60 00000000 00000100 28000000  V+.`........(...
08033120: 00000000 01000000 0f050100 17080100  ................
08033130: 7b080100 00000000 00000000 00000000  {...............
08033140: 00000000 00000000 00000000 00000000  ................
08033150: 00000000 00000000 71090100 00000000  ........q.......
08033160: 00000000 7892890f 00000000 00000000  ....x...........
08033170: 00000000 00000000 00000000 00000000  ................
08033180: 20000000 002369cd 002369cd 24c81da7   ....#i..#i.$...
08033190: c511af60 24c81da7 00000000 00000000  ...`$...........
080331a0: 00000000 00000000 00000000 00000000  ................
080331b0: 00000000 00000000 00000000 00000000  ................
080331c0: 00000000 00000000 00000000 00000000  ................
080331d0: 00000000 00000000 00000000 00000000  ................
080331e0: 00000000 00000000 00000000 00000000  ................
080331f0: 00000000 00000000 00000000 00000000  ................
```

저 두 주소에 가 보자

0x10971000

```
root@oslab-DKU:/home/oslab/2021_DKU_OS/lab3_filesystem# xxd -g 4 -l 0x100 -s 0x10971000 /dev/ramdisk
10971000: 000a0100 00000000 00000000 00000000  ................
10971010: 00000000 00000000 00000000 00000000  ................
10971020: 00000000 00000000 00000000 00000000  ................
10971030: 00000000 00000000 00000000 00000000  ................
10971040: 00000000 00000000 00000000 00000000  ................
10971050: 00000000 00000000 00000000 00000000  ................
10971060: 00000000 00000000 00000000 00000000  ................
10971070: 00000000 00000000 00000000 00000000  ................
10971080: 00000000 00000000 00000000 00000000  ................
10971090: 00000000 00000000 00000000 00000000  ................
109710a0: 00000000 00000000 00000000 00000000  ................
109710b0: 00000000 00000000 00000000 00000000  ................
109710c0: 00000000 00000000 00000000 00000000  ................
109710d0: 00000000 00000000 00000000 00000000  ................
109710e0: 00000000 00000000 00000000 00000000  ................
109710f0: 00000000 00000000 00000000 00000000  ................
```

포인터 처럼 보이는 무언가 있다!! 저 주소 0x10a00000 에 가 보았다!!

0x10a00000

```
root@oslab-DKU:/home/oslab/2021_DKU_OS/lab3_filesystem# xxd -g 4 -l 0x100 -s 0x10a00000 /dev/ramdisk
10a00000: 322f3336 2d330a00 00000000 00000000  2/36-3.........
10a00010: 00000000 00000000 00000000 00000000  ................
10a00020: 00000000 00000000 00000000 00000000  ................
10a00030: 00000000 00000000 00000000 00000000  ................
10a00040: 00000000 00000000 00000000 00000000  ................
10a00050: 00000000 00000000 00000000 00000000  ................
10a00060: 00000000 00000000 00000000 00000000  ................
10a00070: 00000000 00000000 00000000 00000000  ................
10a00080: 00000000 00000000 00000000 00000000  ................
10a00090: 00000000 00000000 00000000 00000000  ................
10a000a0: 00000000 00000000 00000000 00000000  ................
10a000b0: 00000000 00000000 00000000 00000000  ................
10a000c0: 00000000 00000000 00000000 00000000  ................
10a000d0: 00000000 00000000 00000000 00000000  ................
10a000e0: 00000000 00000000 00000000 00000000  ................
10a000f0: 00000000 00000000 00000000 00000000  ................
```

내용이 8/54-4는 아니지만 동일한 크기의 데이터가 저장된 데이터 블록을 발견하였다.

이렇게 4개의 블록을 다 찾았다.

위에서 indirect block 중 하나였던 0x0f899278에도 가 보았지만 아래와 같이 비어있었다.

```
root@oslab-DKU:/home/oslab/2021_DKU_OS/lab3_filesystem# xxd -g 4 -l 0x100 -s 0xf899278 /dev/ramdisk
0f899278: 00000000 00000000 00000000 00000000  ................
0f899288: 00000000 00000000 00000000 00000000  ................
0f899298: 00000000 00000000 00000000 00000000  ................
0f8992a8: 00000000 00000000 00000000 00000000  ................
0f8992b8: 00000000 00000000 00000000 00000000  ................
0f8992c8: 00000000 00000000 00000000 00000000  ................
0f8992d8: 00000000 00000000 00000000 00000000  ................
0f8992e8: 00000000 00000000 00000000 00000000  ................
```

Bouns〉

```
oslab@oslab-DKU:~/2021_DKU_OS/lab3_filesystem$ dmesg | grep park
[ 2618.609972] os_ext2: park jun_yeong OS LAB3
oslab@oslab-DKU:~/2021_DKU_OS/lab3_filesystem$ dmesg | grep os_ext2
[ 2618.609972] os_ext2: park jun_yeong OS LAB3
```

초기 설정은 모두 github의 guide와 동일하게 하였다.

```
 }
 if (EXT2_HAS_COMPAT_FEATURE(sb, EXT3_FEATURE_COMPAT_HAS_JOURNAL))
         ext2_msg(sb, KERN_WARNING,
                  "warning: mounting ext3 filesystem as ext2");
 if (ext2_setup_super (sb, es, sb_rdonly(sb)))
         sb->s_flags |= SB_RDONLY;
 ext2_write_super(sb);
 printk(KERN_INFO "os_ext2: park jun_yeong OS LAB3");
 return 0;
```

super.c 파일에 kernel.h 헤더를 include하고 ext2_fill_super 함수의 마지막 부분에 위와 같은 코드를 추가하였다.

3. discussion

처음에는 이전에 C++언어를 이용해 PE 헤더의 정보를 struct에 read하여 정보를 출력하는 실습을 했었고, 당시에 hex dump editor를 사용해 보았기에 수월하게 읽을 수 있을 것이라고 생각했다. 하지만, 당시에는 16진수로 주소를 직접 계산하지 않았었고, win_hex라는 프로그램을 사용했기에 바이너리 파일의 구조에 맞게 구역을 나누어 볼 수 있는 기능이 있었다. 그러나 이번 실습에서 터미널에서 직접 사용한 xxd는 직접 주소를 계산하여 접근해야해서 약간은 생소한 느낌을 받았다. 하지만, 이렇게 직접 계산을 하고 4byte씩 내용을 읽고(심지어 리틀 엔디안으로!) 숨겨진 영역으로 조금씩 이동하는 것이 마치 보물찾기 같았다. 또한 나중에 취업을 하고 나서 binary file에 접근할 기회가 생긴다면 겁먹지 않고 도전해볼 수 있는 용기를 얻었다.

이번 실습에서 깨달은 점은.. 내가 16진수가 한 글자에 몇 bit씩 차지하는지를 모르고 있었다는 것이다.... 16진수에서 2진수로 바꿀 때 한 글자 당 2진수 4자리씩으로 변환하는 것은 수동으로 계산할 줄을 알면서 16진수 한 자리가 4bit 인 것은 생각조차 하지 않은 것이다. 그래서 4byte씩 출력하는 옵션을 지정하고 첫 화면을 보았을 때 왜 8글자씩 출력 되고, 리틀 엔디안으로 읽을 때 1byte씩 읽어야 하는데 왜 2글자씩 읽는지 이해할 수 없었다. 16진수니까 한 글자 당 16bit씩 차하므로 2byte라는 어이없는 생각을 하고 있었던 것이다... 리틀 엔디안 주소를 도저히 해석할 수 없어서 인터넷에 검색을

한 결과 16진수에서는 한 자리가 4bit에 해당한다는 것을 알았다. 이제라도 알아서 정말 다행이라고 생각했다.

실습 초반에는 8/54 파일 자체를 찾아야 하는 줄 알고 stat 8/54로 아이넘버를 먼저 알아낸 뒤 파일의 data block 자체를 먼저 찾았다. 하지만, 실습 가이드를 다시 보니 root inode 부터 차례로 찾아가야한다는 것을 알고 다시 root inode에 접근했다. 신기했던 것은 수업시간에 '디렉토리는 파일 이름과 아이넘버가 pair로 저장된다.'라고 배운 것을 눈으로 직접 확인할 수 있었던 점이다. 파일 하나하나를 찾아나가는 것이 처음에는 너무 막막했지만 하다보니 정말 재미있었다. 또한 byte 단위로 나눠서 직접 파일시스템의 구조를 보니 수업시간에 배운 내용이 더 이해가 잘 가는 것 같았다.