CES304 Operating System Project3: RAID

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Contents Table

Description of implementation

1. main()

main 함수에서는 다음(두 번째 디스크의 데이터를 읽고, 쓰는 예제 코드)과 같이 FSSIZE를 이용해서 각 disk에서 데이터를 읽고, 쓴다.

```
// 두 번째 디스크의 데이터 읽기
        ret = pread(rdfd, buf1, BSIZE, (i + FSSIZE) * BSIZE);
        if (ret != BSIZE && ret != 0) {
            perror("pread disk 1");
            exit(1);
        }

        // 두 번째 디스크에 데이터 쓰기
        ret = pwrite(wrfd, buf1, BSIZE, (i + FSSIZE) * BSIZE);
        if (ret != BSIZE) {
            perror("pwrite disk 1");
            exit(1);
        }
```

이 때 parity disk에는 disk0과 disk1을 XOR 연산한 데이터를 적는다. XOR 연산은 ^연산자를 활용해서 구현하였다.

```
// XOR 연산으로 패리티 계산
        for (int j = 0; j < BSIZE; j++) {
            parity[j] = disk0_data[j] ^ disk1_data[j];
        }
```

2. dread()

dread 함수에서는 먼저 해당 블록이 BROKEN DISK에 있는지 확인한다. 만약 BROKEN DISK에 있는 데이터가 아니라면, read하고, buf를 return 해준다.

```
  if (disk_num != BROKEN_DISK) { // 고장 나지 않은 disk 의 데이터가
invaild 라면 그냥 다시 읽기
    iderw(b);
    return b;
  }
```

만약 BROKEN DISK에 있는 데이터라면, parity를 활용하여 복구한 다음, vaild로 바꿔준다. 밑은 data disk가 BROKEN일 때의 코드이고, parity disk가 BROKEN일 때도 마찬가지로, disk0과 disk1을 활용해 복구해준다.

```
    b0 = bget_direct(dev, (blockno % FSSIZE) + (((disk_num == 0) ? 1 :
0) * FSSIZE)); // 고장나지 않는 disk 읽기
    iderw(b0);
    bp = bget_direct(dev, (blockno % FSSIZE) + (2 * FSSIZE)); // 패리티
디스크 읽기
    iderw(bp);

    for (int i = 0; i < BSIZE/sizeof(int); i++) {
      b->udata[i] = b0->udata[i] ^ bp->udata[i];
    }

    brelse(b0);
    brelse(bp);
    b->flags |= B_VALID;
```

3. **dwrite()**

dwrite 함수에서는 먼저 기존의 BROKEN DISK의 데이터를 업데이트 한다.

```
if (BROKEN_DISK == (disk_num == 0 ? 1 : 0)) {
    for (int i = 0; i < BSIZE/sizeof(int); i++) {
      b0->udata[i] = b->udata[i] ^ bp->udata[i];
    }
  }
  if (BROKEN_DISK == 2) {
    for (int i = 0; i < BSIZE/sizeof(int); i++) {
      bp->udata[i] = b->udata[i] ^ b0->udata[i];
    }
  }
```

이후 write buf와 이를 바탕으로 다시 새로운 parity를 계산해서 업데이트 한다.

```
// 새로운 패리티 계산
  for (int i = 0; i < BSIZE/sizeof(int); i++) {
    bp->udata[i] = b->udata[i] ^ b0->udata[i];
  }

  // 데이터와 패리티 모두 쓰기
```

```
b->flags |= B_DIRTY;
bp->flags |= B_DIRTY;
```

Result

첨부한 사진을 통해 all possible breakage에 대해 pass한 것을 확인할 수 있다.

jangjiwon@DESKTOP-M4HGQUK: ~/OS/xv6

```
SeaBIOS (version 1.16.0-1)

iPXE (http://ipxe.org) 00:03.0 CA00 PCI2.10 PnP PMM+1FF0B4A0+1FE0B4A0 CA00


Booting from Hard Disk..xv6...
RAID: broken disk is 0
cpu0: starting 0
sb: size 1000 nblocks 941 ninodes 200 nlog 30 logstart 2 inodestart 32 bmap start
init: starting sh
$ usertests
usertests starting
arg test passed
createdelete test
createdelete ok
linkunlink test
linkunlink ok
concreate test
concreate ok
fourfiles test
fourfiles ok
sharedfd test
sharedfd ok
bigarg test
bigarg test ok
bigwrite test
bigwrite ok
bigarg test
bigarg test ok
bss test
bss test ok
sbrk test
pid 97 usertests: trap 14 err 5 on cpu 0 eip 0x8120 addr 0x00000000--kill proc
pid 98 usertests: trap 14 err 5 on cpu 0 eip 0x8120 addr 0x0000a000--kill proc
pid 99 usertests: trap 14 err 5 on cpu 0 eip 0x8120 addr 0x00015ba0--kill proc
pid 100 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x00024ff0--kill proc
pid 101 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x0003dc40--kill proc
pid 102 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x0003d080--kill proc
pid 103 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x00489a0--kill proc
pid 104 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x0066730--kill proc
pid 105 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x0081a50--kill proc
pid 106 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x0082cc20--kill proc
pid 107 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x0007a120--kill proc
pid 108 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x0008470--kill proc
pid 109 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x0083700--kill proc
pid 110 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x0089b10--kill proc
pid 111 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x000aae60--kill proc
pid 112 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x000b71b0--kill proc
pid 113 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x000c8600--kill proc
pid 114 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x000cf050--kill proc
pid 115 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x000dbba0--kill proc
pid 116 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x000e7ef0--kill proc
pid 117 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x0074540--kill proc
pid 118 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x0100580--kill proc
pid 119 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x010c6e0--kill proc
pid 120 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x0116c30--kill proc
pid 121 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x0124f50--kill proc
pid 122 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x0131520--kill proc
pid 123 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x0138520--kill proc
pid 124 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x0149870--kill proc
pid 125 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x0155cc0--kill proc
pid 126 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x0162010--kill proc
pid 127 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x016e380--kill proc
pid 128 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x017e6b0--kill proc
pid 129 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x018a400--kill proc
pid 130 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x0192c60--kill proc
pid 131 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x019f0a0--kill proc
pid 132 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x01ab3f0--kill proc
pid 133 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x01b7740--kill proc
pid 134 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x01c3a90--kill proc
pid 135 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x01cfde0--kill proc
pid 136 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x01dc130--kill proc
allocuvm out of memory
allocuvm out of memory
allocuvm out of memory
allocuvm out of memory
allocuvm out of memory
allocuvm out of memory
allocuvm out of memory
allocuvm out of memory
sbrk test OK
validate test
validate ok
open test
open test ok
small file test
creat small succeeded; ok
writes ok
open small succeeded ok
read succeeded ok
small file test ok
big files test
big files ok
many creates, followed by unlink test
many creates, followed by unlink; ok
openiout test
openiout test ok
exitiout test
exitiout test ok
iout test
iout test ok
mem test
allocuvm out of memory
mem ok
pipe1 ok
preemptc kill... wait... preempt ok
exitwait ok
rmdot test
rmdot ok
fourteen test
fourteen ok
bigfile test
bigfile test ok
subdir test
subdir ok
linktest
linktest ok
unlinkread test
unlinkread ok
dir vs file
dir vs file OK
empty file name
empty file name OK
fork test
fork test OK
bigdir test
bigdir ok
uio test
pid 691 usertests: trap 13 err 0 on cpu 0 eip 0x9857 addr 0x01dc130--kill proc
uio test done
exec test
ALL TESTS PASSED
$
```

jangjiwon@DESKTOP-M4HGQUK: ~/OS/xv6

```
SeaBIOS (version 1.16.0-1)

iPXE (http://ipxe.org) 00:03.0 CA00 PCI2.10 PnP PMM+1FF0B4A0+1FE0B4A0 CA00


Booting from Hard Disk..xv6...
RAID: broken disk is 1
cpu0: starting 0
sb: size 1000 nblocks 941 ninodes 200 nlog 30 logstart 2 inodestart 32 bmap star
init: starting sh
$ usertests
usertests starting
arg test passed
createdelete test
createdelete ok
linkunlink test
linkunlink ok
concreate test
concreate ok
fourfiles test
fourfiles ok
sharedfd test
sharedfd ok
bigarg test
bigarg test ok
bigwrite test
bigwrite ok
bigarg test
bigarg test ok
bss test
bss test ok
sbrk test
pid 97 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x00000000--kill proc
pid 98 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x0000a850--kill proc
pid 99 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x00015ea0--kill proc
pid 100 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x00024ff0--kill proc
pid 101 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x0003d40--kill proc
pid 102 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x0003d090--kill proc
pid 103 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x00049ae0--kill proc
pid 104 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x00056730--kill proc
pid 105 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x00061a50--kill proc
pid 106 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x0006dcc0--kill proc
pid 107 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x00076120--kill proc
pid 108 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x00086470--kill proc
pid 109 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x00092700--kill proc
pid 110 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x0009eb10--kill proc
pid 111 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x000aae60--kill proc
pid 112 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x000b71b0--kill proc
pid 113 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x000c8500--kill proc
pid 114 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x000cf550--kill proc
pid 115 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x000dbbe0--kill proc
pid 116 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x000e7ef0--kill proc
pid 117 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x00074240--kill proc
pid 118 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x00100590--kill proc
pid 119 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x00103e0--kill proc
pid 120 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x00115e30--kill proc
pid 121 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x00124f80--kill proc
pid 122 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x00131c00--kill proc
pid 123 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x0013d820--kill proc
pid 124 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x00148970--kill proc
pid 125 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x00155ac0--kill proc
pid 126 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x00162010--kill proc
pid 127 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x0016e380--kill proc
pid 128 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x0017e6b0--kill proc
pid 129 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x00188a00--kill proc
pid 130 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x00192c60--kill proc
pid 131 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x0019f0e0--kill proc
pid 132 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x001ab370--kill proc
pid 133 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x001b7740--kill proc
pid 134 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x001c3a90--kill proc
pid 135 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x001cfde0--kill proc
pid 136 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x001dc180--kill proc
allocuvm out of memory
allocuvm out of memory
allocuvm out of memory
allocuvm out of memory
allocuvm out of memory
allocuvm out of memory
allocuvm out of memory
allocuvm out of memory
sbrk test OK
validate test
validate ok
open test
open test ok
small file test
creat small succeeded; ok
writes ok
open small succeeded ok
read succeeded ok
small file test ok
big files test
big files ok
many creates, followed by unlink test
many creates, followed by unlink; ok
openiout test
openiout test ok
exitiout test
exitiout test ok
iout test
iout test ok
mem test
allocuvm out of memory
mem ok
pipe1 ok
preemptest: kill... wait... preemptest ok
exitwait ok
rmdot test
rmdot ok
fourteen test
fourteen ok
bigfile test
bigfile test ok
subdir test
subdir ok
linktest
linktest ok
unlinkread test
unlinkread ok
dir vs file
dir vs file OK
empty file name
empty file name OK
fork test
fork test OK
bigdir test
bigdir ok
uio test
pid 691 usertests: trap 18 err 0 on cpu 0 eip 0x8667 addr 0x001dc180--kill proc
uio test done
exec test
ALL TESTS PASSED
$
```

jangjiwon@DESKTOP-M4HGQUK: ~/OS/xv6

```
SeaBIOS (version 1.16.0-1)

iPXE (http://ipxe.org) 00:03.0 CA00 PCI2.10 PnP PMM+1FF0B4A0+1FE0B4A0 CA00


Booting from Hard Disk...xv6...
RAID: broken disk is 2
cpu0: starting 0
sb: size 1000 nblocks 941 ninodes 200 nlog 30 logstart 2 inodestart 32 bmap start
init: starting sh
$ usertests
usertests starting
arg test passed
createdelete test
createdelete ok
linkunlink test
linkunlink ok
concreate test
concreate ok
fourfiles test
fourfiles ok
sharedfd test
sharedfd ok
bigarg test
bigarg test ok
bigwrite test
bigwrite ok
bigarg test
bigarg test ok
bss test
bss test ok
sbrk test
pid 97 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0xb0000000--kill proc
pid 98 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0xb000a350--kill proc
pid 99 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0xb00156a0--kill proc
pid 100 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0xb00248f0--kill proc
pid 101 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0xb0030d40--kill proc
pid 102 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0xb0039d90--kill proc
pid 103 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0xb0049ae0--kill proc
pid 104 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0xb0056730--kill proc
pid 105 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0xb0061a50--kill proc
pid 106 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0xb0069ccc0--kill proc
pid 107 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0xb0071a20--kill proc
pid 108 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0xb0078470--kill proc
pid 109 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0xb0082700--kill proc
pid 110 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0xb0089b10--kill proc
pid 111 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0xb00aae80--kill proc
pid 112 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0xb00b71b0--kill proc
pid 113 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0xb00c3600--kill proc
pid 114 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0xb00cf560--kill proc
pid 115 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0xb00dbba0--kill proc
pid 116 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0xb00e7ef0--kill proc
pid 117 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0xb00f4240--kill proc
pid 118 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0xb0100590--kill proc
pid 119 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0xb0109ce0--kill proc
pid 120 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0xb0118e30--kill proc
pid 121 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0xb0124f50--kill proc
pid 122 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0xb0131c00--kill proc
pid 123 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0xb0138d20--kill proc
pid 124 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0xb0149970--kill proc
pid 125 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0xb0156ce0--kill proc
pid 126 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0xb0162010--kill proc
pid 127 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0xb016e380--kill proc
pid 128 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0xb017a8b0--kill proc
pid 129 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0xb0188a00--kill proc
pid 130 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0xb0192c60--kill proc
pid 131 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0xb019f0d0--kill proc
pid 132 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0xb01ab3f0--kill proc
pid 133 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0xb01b7740--kill proc
pid 134 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0xb01c3a90--kill proc
pid 135 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0xb01cfde0--kill proc
pid 136 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0xb01dc130--kill proc
allocuvm out of memory
allocuvm out of memory
allocuvm out of memory
allocuvm out of memory
allocuvm out of memory
allocuvm out of memory
allocuvm out of memory
allocuvm out of memory
sbrk test OK
validate test
validate ok
open test
open test ok
small file test
writes ok
open small succeeded ok
read succeeded ok
small file test ok
big files test
big files ok
many creates, followed by unlink test
many creates, followed by unlink: ok
dup test
dup test ok
exitiput test
exitiput test ok
iput test
iput test ok
mem test
allocuvm out of memory
mem ok
pipe1 ok
preempt: kill... wait... preempt ok
exitwait ok
rmdot test
rmdot ok
dirfile test
dirfile test ok
mkdir test
mkdir ok
linktest
linktest ok
unlinkread test
unlinkread ok
dir vs file
dir vs file OK
empty file name
empty file name OK
fork test
fork test OK
bigdir test
bigdir ok
uio test
pid 691 usertests: trap 13 err 0 on cpu 0 eip 0x3667 addr 0xb01dc130--kill proc
uio test done
exec test
ALL TESTS PASSED
$
```

jangjiwon@DESKTOP-M4HGQUK: ~/OS/xv6

```
SeaBIOS (version 1.15.0-1)

iPXE (http://ipxe.org) 00:03.0 CA00 PCI2.10 PnP PMM+1FF8B4A0+1FE8B4A0 CA00


Booting from Hard Disk..xv6...
RAID: broken disk 16 -1
cpu0: starting 0
sb: size 1000 nblocks 941 ninodes 200 nlog 30 logstart 2 inodestart 32 bmap start
init: starting sh
$ usertests
usertests starting
sbrk test passed
createdelete test
createdelete ok
linkunlink test
linkunlink ok
concreate test
concreate ok
fourfiles test
fourfiles ok
sharedfd test
sharedfd ok
bigarg test
bigarg test ok
bigwrite test
bigwrite ok
bigarg test
bigarg test ok
bss test
bss test ok
sbrk test
pid 97 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x80000000--kill proc
pid 98 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x8000a850--kill proc
pid 99 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x80015ba0--kill proc
pid 100 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x80024bf0--kill proc
pid 101 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x80030c40--kill proc
pid 102 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x8003c090--kill proc
pid 103 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x80048ae0--kill proc
pid 104 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x80056730--kill proc
pid 105 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x80061a50--kill proc
pid 106 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x80068dd0--kill proc
pid 107 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x80071120--kill proc
pid 108 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x80078470--kill proc
pid 109 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x80082700--kill proc
pid 110 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x8008eb10--kill proc
pid 111 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x8009aae80--kill proc
pid 112 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x800b71b0--kill proc
pid 113 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x800c9600--kill proc
pid 114 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x800d7850--kill proc
pid 115 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x800dbba0--kill proc
pid 116 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x800e7ef0--kill proc
pid 117 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x800f4240--kill proc
pid 118 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x80100590--kill proc
pid 119 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x80110a40--kill proc
pid 120 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x80116e30--kill proc
pid 121 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x80124f00--kill proc
pid 122 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x80131d00--kill proc
pid 123 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x80140820--kill proc
pid 124 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x80149970--kill proc
pid 125 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x80156a00--kill proc
pid 126 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x80162010--kill proc
pid 127 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x80169e80--kill proc
pid 128 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x80176b60--kill proc
pid 129 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x80186a00--kill proc
pid 130 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x80192c60--kill proc
pid 131 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x8019f0a0--kill proc
pid 132 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x801ab370--kill proc
pid 133 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x801b7740--kill proc
pid 134 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x801c3a90--kill proc
pid 135 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x801cfce0--kill proc
pid 136 usertests: trap 14 err 6 on cpu 0 eip 0x8120 addr 0x801dc180--kill proc
allocuvm out of memory
allocuvm out of memory
allocuvm out of memory
allocuvm out of memory
allocuvm out of memory
allocuvm out of memory
allocuvm out of memory
allocuvm out of memory
sbrk test OK
validate test
validate ok
open test
open test ok
small file test
bread small succeeded: ok
writes ok
open small succeeded ok
read succeeded ok
small file test ok
big files test
big files ok
many creates, followed by unlink test
many creates, followed by unlink: ok
opendout test
opendout test ok
exitdout test
exitdout test ok
dout test
dout test ok
mem test
allocuvm out of memory
mem ok
pipe1 ok
preemptest: kill... wait... preemptest ok
exitwait ok
rmdot test
rmdot ok
fourteen test
fourteen ok
bigfile test
bigfile test ok
subdir test
subdir ok
linktest
linktest ok
unlinkread test
unlinkread ok
dir vs file
dir vs file OK
empty file name
empty file name OK
fork test
fork test OK
bigdir test
bigdir ok
uio test
pid 591 usertests: trap 18 err 0 on cpu 0 eip 0x9607 addr 0x801dc180--kill proc
uio test done
exec test
ALL TESTS PASSED
$ _
```

Checking parity Disk

GPT를 사용해서 parity를 확인할 수 있는 코드를 작성해 보았다. 이를 활용하면 shall에서 parity block들이 올바르게 위치했는지 확인할 수 있다.

```
#!/bin/bash

# Usage: ./check_raid.sh <block_number>
if [ $# -ne 1 ]; then
    echo "Usage: $0 <block_number>"
    exit 1
fi

FSSIZE=1000  # filesystem size
BLOCKNO=$1
OFFSET=$((BLOCKNO % FSSIZE))

# Create temporary files
TEMP_DIR=$(mktemp -d)
DISK0="${TEMP_DIR}/disk0"
DISK1="${TEMP_DIR}/disk1"
PARITY="${TEMP_DIR}/parity"

# Extract blocks from each disk
dd if=fs.img bs=512 skip=$OFFSET count=1 of=$DISK0 2>/dev/null
dd if=fs.img bs=512 skip=$((OFFSET + FSSIZE)) count=1 of=$DISK1 2>/dev/null
dd if=fs.img bs=512 skip=$((OFFSET + 2*FSSIZE)) count=1 of=$PARITY 2>/dev/null

# Display the contents
echo "=== Disk 0 (Block $OFFSET) ==="
xxd $DISK0 | head -n 5

echo -e "\n=== Disk 1 (Block $OFFSET) ==="
xxd $DISK1 | head -n 5

echo -e "\n=== Parity Disk (Block $OFFSET) ==="
xxd $PARITY | head -n 5

# Calculate XOR of disk0 and disk1
python3 -c "
import sys
with open('${DISK0}', 'rb') as f0, open('${DISK1}', 'rb') as f1:
    data0 = f0.read()
    data1 = f1.read()
    calc_parity = bytes(a ^ b for a, b in zip(data0, data1))
with open('${TEMP_DIR}/calc_parity', 'wb') as f:
    f.write(calc_parity)
```

```
"

echo -e "\n=== Calculated Parity ==="
xxd "${TEMP_DIR}/calc_parity" | head -n 5

# Compare calculated parity with stored parity
echo -e "\n=== Parity Check Result ==="
if cmp -s "${TEMP_DIR}/calc_parity" "${PARITY}"; then
    echo "SUCCESS: Parity is correct!"
else
    echo "ERROR: Parity mismatch detected!"
    echo "Differences between calculated and stored parity:"
    cmp "${TEMP_DIR}/calc_parity" "${PARITY}"
fi

# Cleanup
rm -rf "${TEMP_DIR}"
```

결과는 다음과 같다. 모든 case에 대해서 확인은 못해 보았지만, 확인해 본 모든 case에서 parity block이 올바르게 위치하고 있는 걸 확인할 수 있다.

```
jangjiwon@DESKTOP-M4HGQUK:~/OS/xv6$ ./debugging.sh 1
=== Disk 0 (Block 1) ===
00000000: e803 0000 ad03 0000 c800 0000 1e00 0000  ................
00000010: 0200 0000 2000 0000 3a00 0000 0000 0000  .... ...:.......
00000020: 0000 0000 0000 0000 0000 0000 0000 0000  ................
00000030: 0000 0000 0000 0000 0000 0000 0000 0000  ................
00000040: 0000 0000 0000 0000 0000 0000 0000 0000  ................

=== Disk 1 (Block 1) ===
00000000: 980d 0000 0000 0000 0000 0000 0000 0000  ................
00000010: 6000 0000 0000 0000 0000 0000 0000 0000  `...............
00000020: 0100 0000 0000 0000 0000 0000 0000 0000  ................
00000030: 0000 0000 0000 0000 0000 0000 0000 0000  ................
00000040: 0000 0000 0000 0000 0000 0000 0000 0000  ................

=== Parity Disk (Block 1) ===
00000000: 700e 0000 ad03 0000 c800 0000 1e00 0000  p...............
00000010: 6200 0000 2000 0000 3a00 0000 0000 0000  b... ...:.......
00000020: 0100 0000 0000 0000 0000 0000 0000 0000  ................
00000030: 0000 0000 0000 0000 0000 0000 0000 0000  ................
00000040: 0000 0000 0000 0000 0000 0000 0000 0000  ................

=== Calculated Parity ===
00000000: 700e 0000 ad03 0000 c800 0000 1e00 0000  p...............
00000010: 6200 0000 2000 0000 3a00 0000 0000 0000  b... ...:.......
00000020: 0100 0000 0000 0000 0000 0000 0000 0000  ................
00000030: 0000 0000 0000 0000 0000 0000 0000 0000  ................
00000040: 0000 0000 0000 0000 0000 0000 0000 0000  ................

=== Parity Check Result ===
SUCCESS: Parity is correct!
```

```
jangjiwon@DESKTOP-M4HGQUK:~/OS/xv6$ ./debugging.sh 300
=== Disk 0 (Block 300) ===
00000000: 6004 0000 7d00 0000 019c 0003 0000 1562  `...}..........b
00000010: 7566 0001 350c 3801 0000 0291 0015 6d61  uf..5.8.......ma
00000020: 7800 0135 1552 0000 0002 9104 0a69 0001  x..5.R.......i..
00000030: 3707 5200 0000 c403 0000 ba03 0000 0a63  7.R............c
00000040: 6300 0137 0a52 0000 000a 0400 0008 0400  c..7.R..........

=== Disk 1 (Block 300) ===
00000000: 980d 0000 0000 0000 0000 0000 0000 0000  ................
00000010: 6000 0000 0000 0000 0000 0000 0000 0000  `...............
00000020: 0100 0000 0000 0000 0000 0000 0000 0000  ................
00000030: 0000 0000 0000 0000 0000 0000 0000 0000  ................
00000040: 0000 0000 0000 0000 0000 0000 0000 0000  ................

=== Parity Disk (Block 300) ===
00000000: f809 0000 7d00 0000 019c 0003 0000 1562  ....}..........b
00000010: 1566 0001 350c 3801 0000 0291 0015 6d61  .f..5.8.......ma
00000020: 7900 0135 1552 0000 0002 9104 0a69 0001  y..5.R.......i..
00000030: 3707 5200 0000 c403 0000 ba03 0000 0a63  7.R............c
00000040: 6300 0137 0a52 0000 000a 0400 0008 0400  c..7.R..........

=== Calculated Parity ===
00000000: f809 0000 7d00 0000 019c 0003 0000 1562  ....}..........b
00000010: 1566 0001 350c 3801 0000 0291 0015 6d61  .f..5.8.......ma
00000020: 7900 0135 1552 0000 0002 9104 0a69 0001  y..5.R.......i..
00000030: 3707 5200 0000 c403 0000 ba03 0000 0a63  7.R............c
00000040: 6300 0137 0a52 0000 000a 0400 0008 0400  c..7.R..........

=== Parity Check Result ===
SUCCESS: Parity is correct!
```

```
jangjiwon@DESKTOP-M4HGQUK:~/OS/xv6$ ./debugging.sh 450
=== Disk 0 (Block 450) ===
00000000: 00cd 40c3 b80a 0000 00cd 40c3 b80b 0000  ..@.......@.....
00000010: 00cd 40c3 b80c 0000 00cd 40c3 b80d 0000  ..@.......@.....
00000020: 00cd 40c3 b80e 0000 00cd 40c3 6690 6690  ..@.......@.f.f.
00000030: 5589 e557 5653 83ec 3c89 4dc4 89d1 8945  U..WVS..<.M....E
00000040: b885 d20f 897f 0000 00f6 4508 0174 79c7  ..........E..ty.

=== Disk 1 (Block 450) ===
00000000: 980d 0000 0000 0000 0000 0000 0000 0000  ................
00000010: 6000 0000 0000 0000 0000 0000 0000 0000  `...............
00000020: 0100 0000 0000 0000 0000 0000 0000 0000  ................
00000030: 0000 0000 0000 0000 0000 0000 0000 0000  ................
00000040: 0000 0000 0000 0000 0000 0000 0000 0000  ................

=== Parity Disk (Block 450) ===
00000000: 98c0 40c3 b80a 0000 00cd 40c3 b80b 0000  ..@.......@.....
00000010: 60cd 40c3 b80c 0000 00cd 40c3 b80d 0000  `.@.......@.....
00000020: 01cd 40c3 b80e 0000 00cd 40c3 6690 6690  ..@.......@.f.f.
00000030: 5589 e557 5653 83ec 3c89 4dc4 89d1 8945  U..WVS..<.M....E
00000040: b885 d20f 897f 0000 00f6 4508 0174 79c7  ..........E..ty.

=== Calculated Parity ===
00000000: 98c0 40c3 b80a 0000 00cd 40c3 b80b 0000  ..@.......@.....
00000010: 60cd 40c3 b80c 0000 00cd 40c3 b80d 0000  `.@.......@.....
00000020: 01cd 40c3 b80e 0000 00cd 40c3 6690 6690  ..@.......@.f.f.
00000030: 5589 e557 5653 83ec 3c89 4dc4 89d1 8945  U..WVS..<.M....E
00000040: b885 d20f 897f 0000 00f6 4508 0174 79c7  ..........E..ty.

=== Parity Check Result ===
SUCCESS: Parity is correct!
```