운영체제

Assignment5

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2019202103

이은비

# **Assignment 5**

## <introduction>

I/O zone을 이용하여 세가지 linux I/O scheduler의 성능을 테스트 해봅니다.

이때 사용하는 linux I/O scheduler는 Noop/CFQ/deadline을 사용합니다. 또한 각각의 record size를 4KB/8KB/16KB/32KB를 각각 3번씩 test해보고 sequential write, sequential read,randomr/w, 임의의 옵션값을 추가하여 그 결과값을 평균값을 낸 후 그 값을 표 및 그래프를 작성합니다. 또한 hardware spec또한 확인한후 상세스펙을 기술합니다.

#### <conclusion>

## <noop scheduler>

```
os2019202103@ubuntu:-/iozone3_471/src/current$ echo noop | sudo tee /sys/block/sda/queue/scheduler
noop
os2019202103@ubuntu:-/iozone3_471/src/current$ cat /sys/block/sda/queue/scheduler
[noop] deadline cfq
os2019202103@ubuntu:-/iozone3_471/src/current$ rm -rf -/izone_test
os2019202103@ubuntu:-/iozone3_471/src/current$ sync
os2019202103@ubuntu:-/iozone3_471/src/current$ echo 3 | sudo tee /proc/sys/vm/drop_caches
3
```

Noop I/O scheduler로 scheduler 를 변경합니다. 그리고 test이전 에 캐시 및 버퍼를 비우는 과정 을 거친 뒤 test를 시작합니다.

# (4kb) 3번의 실습을 통해 4kb의 옵션의 결과값의 평균값을 구합니다.

```
Contributors:William Norcott, Don Capps, Isom Crawford, Kirby Collins
Al Slater, Scott Rhine, Mike Wisner, Ken Goss
Steve Landherr, Brad Smith, Mark Kelly, Dr. Alain CYR,
Randy Dunlap, Mark Montague, Dan Million, Gavin Brebner,
Jean-Marc Zucconi, Jeff Blomberg, Benny Halevy, Dave Boone,
Erik Habbinga, Kris Strecker, Walter Wong, Joshua Root,
Fabrice Bacchella, Zhenghua Xue, Qin Li, Darren Sawyer,
Vangel Bojaxhi, Ben England, Vikentsi Lapa,
Alexey Skidanov.
             Run began: Thu Dec 9 07:44:35 2021
              Include fsync in write timing
O_DIRECT feature enabled
             O_DIRECT feature enabled
Auto Mode
File size set to 4096 kB
Record Size 4 kB
Record Size 4 kB
Command line used: iozone -e -I -a -s 4m -r 4k -r 4k -i 0 -i 1 -i 2 -i 3 -i 4
Output is in kBytes/sec
Time Resolution = 0.000001 seconds.
Processor cache size set to 1024 kBytes.
Processor cache line size set to 32 bytes.
File stride size set to 17 * record size.

random random bkw
                                                                                                                                                                                   fwrite frewrite
iozone test complete.
                                                                                                                            random
                                                                                                                                               bkwd
                                                                                                          random
                                                                                                                                                            record
                                                                                                                                                                               stride
                                                                                                                             write
18234
                                                                                                                                                                                                                          fread freread
                            reclen
                                              write rewrite
                                                                              read
                                                                                                                                               read
                                                                                                                                                           rewrite
                                                                                                                                                                                 read
                                                                                                                                                                                             fwrite frewrite
                                                                                            reread
                                                                                                             read
                                              26568
                                                              28360
                                                                              30861
                                                                                              30046
                                                                                                             19680
                                                                                                                                                              16770
.ozone test complete.
                                                                                                                                                    bkwd
                                                                                                                                                                                       stride
                                                                                                          random
                                                                                                                               random
                                                                                                                                                                   record
                                                                                                                                                                                                         fwrite frewrite
                                                                                                                                                                                                                                              fread freread
                                       write rewrite
            kB
                  reclen
                                                                           read
                                                                                           reread
                                                                                                              read
                                                                                                                                write
                                                                                                                                                   read
                                                                                                                                                                 rewrite
                                                                                                                                                                                           read
         4096
                                        25376
                                                         27404
                                                                           28609
                                                                                             29156
                                                                                                              25826
                                                                                                                                27524
                                                                                                                                                  18518
                                                                                                                                                                      18889
test complete.
   Wirte
                                 Rewrite
                                                                                               Reread
                                                                                                                              Randomread
                                                                                                                                                                      Randomwrite
                                                                                                                                                                                                                 Bkwdread
                                                                                                                                                                                                                                                   Record
                                                                Read
                                                                                                                                                                                                                                                   rewrite
                                                                                              28014
                                                                                                                                                                      22908
                                                                                                                                                                                                                                                   19964
   26434
                                27456
                                                                28808
                                                                                                                             22877
                                                                                                                                                                                                                 20185
```

```
(8kb)
  os2019202103@ubuntu:-/iozone3_471/src/current$ iozone -e -I -a -s 4m -r 8k -r 8k -i 0 -i 1 -i 2 -i 3 -i 4
Iozone: Performance Test of File I/O
Version $Revision: 3.471 $
Compiled for 64 bit mode.
Build: linux-arm
            Contributors: William Morcott, Don Capps, Isom Crawford, Kirby Collins Al Slater, Scott Rhine, Mike Wisner, Ken Goss Steve Landherr, Brad Smith, Mark Kelly, Dr. Alain CYR, Randy Dunlap, Mark Montague, Dan Million, Gavin Brebner, Jean-Marc Zucconi, Jeff Blomberg, Benny Halevy, Dave Boone, Erik Habbinga, Kris Strecker, Walter Wong, Joshua Root, Fabrice Bacchella, Zhenghua Xue, Qin Li, Darren Sawyer, Vangel Bojaxhi, Ben England, Vikentsi Lapa, Alexey Skidanov.
              Run began: Thu Dec 9 07:45:21 2021
             Include fsync in write timing
O_DIRECT feature enabled
Auto Mode
File size set to 4096 kB
Record Size 8 kB
Record Size 8 kB
Command line used: iozone -e -I -a -s 4m -r 8k -r 8k -i 0 -i 1 -i 2 -i 3 -i 4
Output is in kBytes/sec
Time Resolution = 0.000001 seconds.
Processor cache size set to 1024 kBytes.
Processor cache line size set to 32 bytes.
File stride size set to 17 * record size.
                                                                                                                                                        record stride
rewrite read fwrite frewrite fread freread
57348
                    kB reclen write rewrite read
4096 8 47148 59939 61260
iozone test complete.
                                                                                                                                              bkwd
                                                                                                                            random
                                                                                                                                                                              stride
                                                                                                          random
                                                                                                                                                             record
                   kB reclen write rewrite
4096 8 47175 48974
                                                                                            reread
                                                                                                           read
35596
                                                                                                                             write
                                                                                                                                              read
                                                                                                                                                                                read fwrite frewrite fread freread
                                                                             read
                                                                                                                                                           rewrite
                                                                             58410
                                                                                             48271
                                                                                                                                             37106
                                                                                                                             36911
                                                                                                                                                              36027
iozone test complete.
                                                                                                        random
                                                                                                                         random
                                                                                                                                           bkwd
                                                                                                                                                         record
                                                                                                                                                                          stride
                    kB reclen write rewrite
1096 8 44487 57095
                                                                            read
                                                                                         reread
                                                                                                                                           read
                                                                                                                                                        rewrite
                                                                                                                                                                            read fwrite frewrite fread freread
                                                                                                          read
                                                                                                                          write
                  4096
                                                                                           57351
                                                                                                                                          49954
                                                                                                                                                          32960
                                                                            52695
                                                                                                          55787
                                                                                                                          59608
  zone test comple
   Wirte
                               Rewrite
                                                              Read
                                                                                           Reread
                                                                                                                         Randomread
                                                                                                                                                               Randomwrite
                                                                                                                                                                                                        Bkwdread
                                                                                                                                                                                                                                        Record
                                                                                                                                                                                                                                        rewrite
   46270
                               55336
                                                              57455
                                                                                          58902
                                                                                                                        52540
                                                                                                                                                               52965
                                                                                                                                                                                                        50043
                                                                                                                                                                                                                                        42112
(16kb)
```

Iozone: Per Ver Cor	u:~/iozone3_471/src rformance Test of F rsion \$Revision: 3. mpiled for 64 bit m ild: linux-arm	ile I/O 471 \$	-I -a -s 4m -r 16ŀ	k -r 16k -i 0 -i 1 -i 2 -i	l 3 -i 4									
Contributo	Contributors:William Norcott, Don Capps, Isom Crawford, Kirby Collins Al Slater, Scott Rhine, Mike Wisner, Ken Goss Steve Landherr, Brad Snith, Mark Kelly, Dr. Alain CYR, Randy Duniap, Mark Montague, Dan Million, Gavin Brebner, Jean-Marc Zuccont, Jeff Blonberg, Benny Halevy, Dave Boone, Erik Habbinga, Kris Strecker, Walter Wong, Joshua Root, Fabrice Bacchella, Zhenghua Xue, Qin Li, Darren Sawyer, Vangel Bojanki, Ben England, Vikentsi Lapa, Alexey Skidanov.													
	Thu Dec 9 07:46:0													
Include fs O_DIRECT fo Auto Mode	ync in write timing eature enabled													
	set to 4096 kB													
Record Size		-I -a -s 4m -r 16k	-r 16k -i 0 -i 1 -i	12-13-14										
Output is	in kBytes/sec ution = 0.000001 se													
Processor	cache size set to 1 cache line size set	to 32 bytes.												
	e size set to 17 *			ndom bkwd record	stride									
kB 1 4096	reclen write re 16 57671			rite read rewrite 5893 78479 78233	read fwrite frewrite	fread freread								
iozone test comple	te. <del>.uc's.zc 3c'''' 1</del>	<del>/                                      </del>												
kB		rewrite rea		dom random bkwo ead write read		fwrite frewrite	fread freread							
4096	16 87562			2639 110598 10449		TWITTE THEWITTE	Tread Trefead							
ozone test compl	lete.													
kВ г 4096	eclen write r 16 84208	ewrite read 105861 88004	random reread read 108362 97163	write read rew	cord stride rite read fwrite 9100	frewrite fread	freread							
zone test complet	e.			·										
Wirte	Rewrite	Read	Reread	Randomread	Randomwrite	Bkwdread	Record							
							rewrite							
76480	96537	89929	99062	97685	97807	92480	98854							

## (32kb)

```
Contributors:William Norcott, Don Capps, Isom Crawford, Kirby Collins
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Steve Landherr, Brad Smith, Mark Kelly, Dr. Alain CYR,
Randy Dunlap, Mark Montague, Dan Million, Gavin Brebner,
Jean-Marc Zucconi, Jeff Blomberg, Benny Halevy, Dave Boor
Erik Habbinga, Kris Strecker, Walter Wong, Joshua Root,
Fabrice Bacchella, Zhenghua Xue, Qin Li, Darren Sawyer,
Vangel Bojaxhi, Ben England, Vikentsi Lapa,
                   lude fsync in write timing
IRECT feature enabled
                    Mode

size set to 4096 kB

rd size 32 kB

rd size 32 kB

and line used: fozone -e -I -a -s 4m -ut is in kBytes/sec

Resolution = 0.000001 seconds.

essor cache size set to 1024 kBytes.
essor cache line size set to 32 bytes.
estride size set to 17 * record size.
                                                 iozone -e -I -a -s 4m -r 32k -r 32k -i 0 -i 1 -i 2 -i 3 -i 4
                                                                                                      reread read
211276 18<u>6776</u>
                                                                                                                                                                                                                   fwrite frewrite
                                                                                                                                                                                                      stride
read fwrite frewrite
                                                                                                                                                                                                                                                             fread freread
                                                                                    read
230216
                                                                                                                                                                                                                    stride
read
                                                                                                                                                                                                                                     fwrite frewrite
                                                                                                                                                                                                                                                                               fread freread
                                                   write rewrite read
163128 160975 175854
                                                                                                           reread
157581
Wirte
                                   Rewrite
                                                                      Read
                                                                                                         Reread
                                                                                                                                            Randomread
                                                                                                                                                                                           Randomwrite
                                                                                                                                                                                                                                           Bkwdread
                                                                                                                                                                                                                                                                                  Record
                                                                                                                                                                                                                                                                                 rewrite
138223
                                  158777
                                                                      203610
                                                                                                                                                                                           192366
                                                                                                                                                                                                                                                                                  203857
                                                                                                         189460
                                                                                                                                            198244
                                                                                                                                                                                                                                           197143
```

## Noop scheduler의 옵션 결과값(평균값)table

Byte	Wirte	Rewrite	Read	Reread	Randomread	Randomwrite	Bkwdread	Record
								rewrite
4kb	26434	27456	28808	28014	22877	22908	20185	19964
8kb	46270	55336	57455	58902	52540	52965	50043	42112
16kb	76480	96537	89929	99062	97685	97807	92480	98854
32kb	138223	158777	203610	189460	198244	192366	197143	203857

## <옵션값 항목>//보고서 추가사항

0 = write/re-write, 1 = read/re-read, 2 = random-read/write, 3 = read-backwards,

4 = re-write-record, 5 = stride-read, 6 = fwrite/re-fwrite, 7 = fread/re-fread,

8 = random mix, 9 = pwrite/re-pwrite, 10 = pread/re-pread, 11 = pwritev/re-pwritev,

12 = preadv/re-preadv

에서 sequential 값인 0,1과 random r/w인 2, read-backwards인 3, re-write-record값을 선택했습니다. 3과 4를 옵션값을 선택한이유는 file의 속도를 defult값이 너무 커서 실습하는데 시간이 오래 걸려 4MB로 하였는데 6,7과 같은 값은 file의 크기를 생각보다 작게하여 오류가 생길 수있어 그에 영향을 받지않는 옵션을 선택하였습니다.

#### <deadline>

```
os2019202103@ubuntu:~/iozone3_471/src/current$ echo deadline | sudo tee /sys/block/sda/queue/scheduler
deadline
os2019202103@ubuntu:~/iozone3_471/src/current$ cat /sys/block/sda/queue/scheduler
noop [deadline] cfq
os2019202103@ubuntu:~/iozone3_471/src/current$ rm -rf ~/izone_test
os2019202103@ubuntu:~/tozone3_471/src/current$ sync
os2019202103@ubuntu:~/tozone3_471/src/current$ echo 3 | sudo tee /proc/sys/vm/drop_caches
```

deadline I/O scheduler로 scheduler를 변경합니다. 그리고 test이전에 캐시 및 버퍼를 비우는 과정을 거친 뒤 test를 시작합니다.

#### (4kb)

```
untu:-/tozone3_471/src/current$ tozone -e -I -a -s 4m -r 4k -r 4k -i 0 -i 1 -i 2 -i 3 -i 4
Performance Test of File I/O
Version Skevision: 3,471 $
Complied for 64 bit mode.
Build: linux-arm
              Contributors:William Norcott, Don Capps, Isom Crawford, Kirby Collins
Al Slater, Scott Rhine, Mike Wisner, Ken Goss
Steve Landherr, Brad Smith, Mark Kelly, Dr. Alain CYR,
Randy Dunlap, Mark Montague, Dan Million, Gavin Brebner,
Jean-Marc Zucconi, Jeff Blomberg, Benny Halevy, Dave Boone,
Erik Habbinga, Kris Strecker, Walter Wong, Joshua Rock,
Fabrice Bacchella, Zhenghua Xue, Qin Li, Darren Sawyer,
Vangel Bojaxhi, Ben England, Vikentsi Lapa,
Alexey Skidanov.
                Run began: Thu Dec 9 07:50:12 2021
              Include fsync in write timing
O_DIRECT feature enabled
Auto Mode
File size set to 4096 kB
Record Size 4 kB
Record Size 4 kB
Command line used: iozone -e -I -a -s 4m -r 4k -r 4k -i 0 -i 1 -i 2 -i 3 -i 4
Output is in kBytes/sec
Time Resolution = 0.000001 seconds.
Processor cache size set to 1024 kBytes.
Processor cache line size set to 32 bytes.
File stride size set to 17 * record size.

random random bkw
                                                                                                                                                   random
write
25819
                                                                                                                                                                                                              stride
read fwrite frewrite fread freread
                        kB reclen write rewrite
4096 4 24048 28536
                                                                                             read
28641
iozone test complete.
                                                                                                                                                                                     record
rewrite
28772
                                                                                                                                                                                                                            fwrite frewrite
                   kB reclen
                                                                                                                                                                                                                                                                    fread freread
                                                   write rewrite
28816 29989
                                                                                                                               read
29156
                                                                                                          reread
31407
                                                                                          read
29762
 one test complete.
                                                                                                                                                                                  record
rewrite
29580
                                                                                                                                                random
write
29811
                                                                                                                                                                   bkwd
read
30009
                                                                                                                                                                                                          stride
read fwrite frewrite
                       kB reclen write rewrite
4096 4 29246 29887
                                                                                                                              read
28079
                                                                                           read
31594
                                                                                                           reread
33423
  Wirte
                                       Rewrite
                                                                              Read
                                                                                                                   Reread
                                                                                                                                                         Randomread
                                                                                                                                                                                                           Randomwrite
                                                                                                                                                                                                                                                               Bkwdread
                                                                                                                                                                                                                                                                                                        Record
                                                                                                                                                                                                                                                                                                        rewrite
  27370
                                       29471
                                                                             29999
                                                                                                                  31128
                                                                                                                                                         28016
                                                                                                                                                                                                           27945
                                                                                                                                                                                                                                                               28830
                                                                                                                                                                                                                                                                                                        28914
```

#### (8kb)

```
ps2019202103@ubuntu:-/lozone3_471/src/current$ lozone -e -I -a -s 4m -r 8k -r 8k -i 0 -i 1 -i 2 -i 3 -i 4
Iozone: Performance Test of File I/O
Version SRevision: 3.471 $
Compiled for 64 bit mode.
Build: linux-arm
                     Contributors:William Norcott, Don Capps, Isom Crawford, Kirby Collins
Al Slater, Scott Rhine, Mike Wisner, Ken Goss
Steve Landherr, Brad Smith, Mark Kelly, Dr. Alain CYR,
Randy Dunlap, Mark Montague, Dan Million, Gavin Brebner,
Jean-Marc Zucconi, Jeff Blomberg, Benny Halevy, Dave Boone,
Erlk Habbinga, Kris Strecker, Walter Wong, Joshua Root,
Fabrice Bacchella, Zhenghua Xue, Qin Li, Darren Sawyer,
Vangel Bojaxhi, Ben England, Vikentsi Lapa,
Alexey Skidanov.
                       Run began: Thu Dec 9 07:51:40 2021
                      Include fsync in write timing
0_DIRECT feature enabled
Auto Mode
File size set to 4096 kB
Record Size 8 kB
Record Size 8 kB
Command line used: iozone -e -I -a -s 4m -r 8k -r 8k -i 0 -i 1 -i 2 -i 3 -i 4
Output is in kBytes/sec
Time Resolution = 0.000001 seconds.
Processor cache size set to 1024 kBytes.
Processor cache size set to 1024 kBytes.
File stride size set to 17 * record size.

random random bkw
                                                                                                                                                                                       random
read
53318
                                                                                                                                                                                                                                                                            record
rewrite
53254
                                                                                                                                                                                                                                                                                                               stride
read fwrite frewrite fread freread
                                  kB reclen write rewrite read reread
4096 8 53612 60116 58949 55301
iozone test complete.
```

kB 4096 iozone test compl	8 49741	rewrite read 54014 53534	random reread read 59333 53908	write read re	ecord stride write read fwrite 53775	frewrite fread	freread
kB r 4096 ozone test complet		ewrite read 58309 58270		random bkwd record write read rewrite 62083 63640 55310	read fwrite frew	rite fread frere	ad
Wirte	Rewrite	Read	Reread	Randomread	Randomwrite	Bkwdread	Record rewrite
50345	57480	56918	56767	53131	54865	55781	54115

#### (16kb)

```
Contributors:William Norcott, Don Capps, Isom Crawford, Kirby Collins
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Randy Dunlap, Mark Montague, Dan Million, Gavin Brebner,
Jean-Marc Zucconi, Jeff Blomberg, Benny Halevy, Dave Boone,
Erik Habbinga, Kris Strecker, Walter Wong, Joshua Root,
Fabrice Bacchella, Zhenghua Xue, Qin Li, Darren Sawyer,
Vangel Bojaxhi, Ben England, Vikentsi Lapa,
Alexey Skidanov.
               Run began: Thu Dec 9 07:52:13 2021
               Include fsync in write timing
O_DIRECT feature enabled
Auto Mode
File size set to 4096 kB
Record Size 16 kB
Record Size 16 kB
Command line used: iozone -e -I -a -s 4m -r 16k -r 16k -i 0 -i 1 -i 2 -i 3 -i 4
Output is in kBytes/sec
Time Resolution = 0.000001 seconds.
Processor cache size set to 1024 kBytes.
Processor cache line size set to 32 bytes.
File stride size set to 17 * record size.

random random bkwd
                                                                                                                                                                                           stride read fwrite frewrite fread freread
                      kB reclen write rewrite read
4096 16 98779 107317 112406
                                                                                                                   random
                                                                                                                                                         bkwd
                     kB reclen write rewrite read reread read
4096 16 102344 108445 131712 144143 106928
                                                                                                                                      write
                                                                                                                                                         read
                                                                                                                                                                      rewrite
                                                                                                                                                                                             read fwrite frewrite fread freread
                                                                                                                                      94113
                                                                                                                                                    105287
ozone test complete.
                                                                                                                                      random
                                                                                                                                                          bkwd
read
                                                                                                                   random
                                                                                                                                                                        record
rewrite
124445
                        kB reclen write rewrite read
196 16 89208 137306 114177
                                                                                                    reread read
109735 104300
                                                                                                                                                                                                            fwrite frewrite fread freread
                                                                                                                                      107436
                                                                                                                                                       123611
lozone test complete.
   Wirte
                                  Rewrite
                                                                    Read
                                                                                                     Reread
                                                                                                                                      Randomread
                                                                                                                                                                                  Randomwrite
                                                                                                                                                                                                                                Bkwdread
                                                                                                                                                                                                                                                                    Record
                                                                                                                                                                                                                                                                    rewrite
                                                                                                                                                                                                                                                                    102634
  96777
                                  117689
                                                                    119432
                                                                                                     126191
                                                                                                                                      108405
                                                                                                                                                                                  108010
                                                                                                                                                                                                                                118948
```

#### (32kb)

```
oszolszazione in write timing
O Direct Fround wite timing
O Direct Fround wite timing
O Direct Sync in write timing
O Direct Size 32 kB
Record Size 32 kB
Re
```

kB 4096 iozone test comple	32 163244	rewrite read 172070 211854	random reread read 209482 196346	write read re	ecord stride write read fwrite 74796	e frewrite fread	freread				
random random bkwd record stride kB reclen write rewrite read reread read write read rewrite read fwrite frewrite fread freread 4096 32 94293 93809 92324 210755 211307 129929 187561 158037 one test complete.											
Wirte	Rewrite	Read	Reread	Randomread	Randomwrite	Bkwdread	Record rewrite				
131590	172884	217462	200962	178663	211876	208897	199757				

## Deadline scheduler 옵션값(평균값) table

Byte	Wirte	Rewrite	Read	Reread	Randomread	Randomwrite	Bkwdread	Record
								rewrite
4kb	27370	29471	29999	31128	28016	27945	28830	28914
8kb	50345	57480	56918	56767	53131	54865	55781	54115
16kb	96777	117689	119432	126191	108405	108010	118948	102634
32kb	131590	172884	217462	200962	178663	211876	208897	199757

## <CFQ scheduler>

```
os2019202103@ubuntu:~/iozone3_471/src/current$ cat /sys/block/sda/queue/scheduler
noop [deadline] cfq
os2019202103@ubuntu:~/iozone3_471/src/current$ echo cfq | sudo tee /sys/block/sda/queue/scheduler
cfq
os2019202103@ubuntu:~/iozone3_471/src/current$ cat /sys/block/sda/queue/scheduler
noop deadline [cfq]
os2019202103@ubuntu:~/iozone3_471/src/current$ rm -rf ~/izone_test
os2019202103@ubuntu:~/iozone3_471/src/current$ sync
os2019202103@ubuntu:~/iozone3_471/src/current$ echo 3 | sudo tee /proc/sys/vm/drop_caches
3
os2019202103@ubuntu:~/iozone3_471/src/current$
```

CFQ I/O scheduler로 scheduler를 변경합니다. 그리고 test이전에 캐시 및 버퍼를 비우는 과정을 거친 뒤 test를 시작합니다.

## (4kb)

```
os2019202103@ubunkus:-/loconed_ aft/grc/current$ tozone -e -I -a -s 4m -r 4k -r 4k -l 6 -l 1 -l 2 -l 3 -l 4

Iozone: Performance Test of File I/O

Version SRevision: 3.471 $

Compiled for 64 bit mode.

Build: Ilnux-arm

Contributors:William Norcott, Don Capps, Ison Crawford, Kirby Collins

Al Silater, Scott Rhine, Mike Wisner, Ken Goss

Steve Landherr, Brad Smith, Mark Kelly, Or. Alain CVR,

Randy Dunlap, Mark Montague, Dan Million, Gavin Brebner,

Jean-Marc Zucconi, Jeff Blonberg, Benny Malevy, Dave Boone,

Erik Habbinga, Kris Strecker, Walter Wong, Joshua Root,

Fabrice Bacchella, Zhenghua Aue, Qin Li, Darren Sawyer,

Vangel Bojawhi, Ben England, Vikentsi Lapa,

Alexey Skidanov.

Run began: Thu Dec 9 07:55:37 2021

Include fsync in write tining

O_DIRECT feature enabled

Auto Mode

File size set to 4096 kB

Record Size 4 kB

Record Size 4 kB

Command line used: lozone -e -I -a -s 4m -r 4k -r 4k -l 0 -l 1 -l 2 -l 3 -l 4

Output is in kBytes/sec

Time Resolution = 0.000001 seconds.

Processor cache size set to 1024 kBytes.

Processor cache line size set to 1024 kBytes.

Processor cache line size set to 1024 kBytes.

File stride size set to 17 * record size.

RB reclen write rewrite read reread write read rewrite read fwrite frewrite fread freread

4096 4 25634 23255 23232 25815 26644 26336 26023 24480

lozone test complete.
```

kB 4096		write 20337	rewrite 20760	read 23311	reread 25524	random read 25026	random write 23766	bkwd read 23084	reco rewri	ite read	fwrite fr	ewrite fread	freread
kB 4096	4 2	vrite 23161	rewrite 22075	read 24269	reread 25970	random read 25756	random write 24333	bkwd read 24895	reco rewri 245	te read	fwrite fre	ewrite fread	freread
Wirte	Rewrit	te	Reac	k	Rere	ead	Ranc	lomre	ad	Randon	nwrite	Bkwdread	Record rewrite
23044	22030	)	2360	)4	257	70	2580	9		24817		24667	23665

#### (8kb)

```
ocs: Comprece.

20103@ubuntu:-/iozone3_471/src/current$ iozone -e -I -a -s 4m -r 8k -r 8k -i 0 -i 1 -i 2 -i 3 -i 4

Iozone: Performance Test of File I/O

Version SRevision: 3.471 $

Compiled for 64 bit mode.

Build: linux-arm
             Contributors:William Norcott, Don Capps, Isom Crawford, Kirby Collins
Al Slater, Scott Rhine, Mike Misner, Ken Goss
Steve Landherr, Brad Smith, Mark Kelly, Dr. Alain CYR,
Randy Dunlap, Mark Montague, Dan Million, Gavin Brebner,
Jean-Marc Zuccont, Jeff Blomberg, Benny Halevy, Dave Boone,
Erik Habbinga, Kris Strecker, Walter Wong, Joshua Root,
Fabrice Bacchella, Zhenghua Xue, Qin Li, Darren Sawyer,
Vangel Bojaxhi, Ben England, Vikentsi Lapa,
Alexey Skidanov.
              Run began: Thu Dec 9 07:56:13 2021
              Include fsync in write timing O_DIRECT feature enabled
              O_DIRECT feature enabled
Auto Mode
File size set to 4096 kB
Record Size 8 kB
Command line used: iozone -e -I -a -s 4m -r 8k -r 8k -i 0 -i 1 -i 2 -i 3 -i 4
Output is in kBytes/sec
Time Resolution = 0.000001 seconds.
Processor cache size set to 1024 kBytes.
Processor cache line size set to 32 bytes.
File stride size set to 17 * record size.

random random bkw
                                                                                                                                                    bkwd
read
57772
                                                                                                                                 random
write
53354
                                                                                                                                                                  record stride
rewrite read fwrite frewrite fread freread
50615
                     kB reclen write rewrite read reread
4096 8 40566 41460 47766 49507
iozone test complete.
File Stride Size Set to 1/ * record Size.
                                                                                                                        random
read
57818
                                                                                                                                              random
                                                                                                                                                                    bkwd
                                                                                                                                                                                  record
                                                                                                                                                                                                        stride
read
                          kB reclen write rewrite
096 8 40680 40833
                                                                                                         reread
57758
                                                                                                                                               write
49860
                                                                                                                                                                  read
60421
                                                                                                                                                                                 rewrite
50495
                                                                                         read
52368
                                                                                                                                                                                                                      fwrite frewrite fread freread
iozone test complete.
                                                                                                                       random
                                                                                                                                                                 bkwd
                                                                                                                                                                                                     stride
                       kB reclen write 1
1096 8 36756
                                                                                                                                             write
50315
                                                                                                                                                                               rewrite
45432
                                                   write rewrite
                                                                                       read
                                                                                                        reread
                                                                                                                          read
                                                                                                                                                                 read
                                                                                                                                                                                                        read fwrite frewrite fread freread
                    4096
                                                                                                                                                               52244
                                                                    37735
                                                                                        46728
                                                                                                         51681
                                                                                                                           50502
ozone test complete.
   Wirte
                                      Rewrite
                                                                          Read
                                                                                                              Reread
                                                                                                                                                  Randomread
                                                                                                                                                                                                Randomwrite
                                                                                                                                                                                                                                                  Bkwdread
                                                                                                                                                                                                                                                                                         Record
                                                                                                                                                                                                                                                                                         rewrite
```

### (16kb)

39334

40009

48954

52982

```
De2019202103@ubuntur:-/ivacene3 471/arc/current$ lozone -e -I -a -s 4m -r 16k -r 16k -i 0 -i 1 -i 2 -i 3 -i 4

Iozone: Per formance mask of file 0

Version Skevision: 3.471 $

Compiled for 64 bit mode.

Build: linux-arm

Contributors: Nilliam Norcott, Don Cappa, Ison Crawford, Kirby Collins

Al Slave Scott Bhinse Hike Withers Kee Goss

Steve Landherr, Brad Swith, Hark Keily, Dr. Alain CYR,

Randy Dunlap, Mark Montague, Dan Million, Gavin Brebner,

Jean-Marc Zuccont, Jeff Blomberg, Benny Halevy, Dave Boone,

Erik Habbinga, Kris Strecker, Walter Wong, Joshua Root,

Fabrice Bacchella, Zhenghua Xue, Qin Li, Darren Sawyer,

Vanget Bojaxht, Ben England, Vikentsi Lapa,

Run began: Thu Dec 9 07:56:44 2021

Include Fsync in write timing

DIMICT Sature enabled

Alexey Skidanov.

Record Size 16 kB

Record Size 16 kB

Record Size 16 kB

Record Size 16 kB

Command line used: Lozone -e -I -a -s 4m -r 16k -r 16k -i 0 -i 1 -i 2 -i 3 -i 4

Original Record Size 16 kB

Command Line used: Lozone -e -I -a -s 4m -r 16k -r 16k -i 0 -i 1 -i 2 -i 3 -i 4

Original Record Size 16 kB

Command Line used: Lozone -e -I -a -s 4m -r 16k -r 16k -i 0 -i 1 -i 2 -i 3 -i 4

Original Record Size 16 kB

Record Size 10 kB

Record S
```

55283

51176

56812

48847

ozone test	4096	reclen 16	write 70711	rewrite 58598	read 70770	reread 82432	random read 89037	random write 98143	bkwd read 101220	record rewrite 80225	stride read	fwrite frewrite	fread freread
iozone tes	4096		write 6129	e rewrite 1 71923	read 73748	rereac 107001		randor write 104500	е геа	d rewrite	ге	de ad fwrite frewrit	e fread freread

Wirte	Rewrite	Read	Reread	Randomread	Randomwrite	Bkwdread	Record
							rewrite
61521	62560	74441	92620	99728	99405	105545	79173

(32kb)

```
untu:-/lozone3_471/src/current$ lozone -e -I -a -s 4m -r 32k -r 32k -i 0 -i 1 -i 2 -i 3 -i 4
Performance Test of File I/O
Version SRevision: 3.471 $
Compiled for 64 bit mode.
Build: linux-arm
              Contributors:William Norcott, Don Capps, Isom Crawford, Kirby Collins
Al Slater, Scott Rhine, Mike Wisner, Ken Goss
Steve Landherr, Brad Smith, Mark Kelly, Dr. Alain CYR,
Randy Dunlap, Mark Montague, Dan Million, Gavin Brebner,
Jean-Marc Zucconi, Jeff Blomberg, Benny Halevy, Dave Boone,
Erik Habbinga, Kris Strecker, Malter Wong, Joshua Rock,
Fabrice Bacchella, Zhenghua Xue, Qin Li, Darren Sawyer,
Vangel Bojaxhi, Ben England, Vikentsi Lapa,
Alexey Skidanov.
               Run began: Thu Dec 9 07:57:23 2021
              Include fsync in write timing
O_DIRECT feature enabled
Auto Mode
File size set to 4096 kB
Record Size 32 kB
Record Size 32 kB
Command line used: tozone -e -I -a -s 4m -r 32k -r 32k -i 0 -i 1 -i 2 -i 3 -i 4
Output is in kBytes/sec
Time Resolution = 0.000001 seconds.
Processor cache size set to 1024 kBytes.
Processor cache line size set to 32 bytes.
File stride size set to 17 * record size.

random random bkwd
                       kB reclen write rewrite read reread random random bkwd
4096 32 92098 93162 113440 148665 214799 130098 173853
                                                                                                                                                                                   record
rewrite
160785
                                                                                                                                                                                                           stride
read fwrite frewrite fread freread
 lozone test complete.
                                                                                                                                          random
                                                                                                                                                                random
                                                                                                                                                                                        bkwd
                                                                                                                                                                                                           record
                                                                                                                                                                                                                                  stride
                                                           write rewrite
                                                                                                                                                                                                                                      read fwrite frewrite fread freread
                           kB reclen
                                                                                                    read
                                                                                                                       reread
                                                                                                                                                                  write
                                                                                                                                                                                        read
                                                                                                                                                                                                         rewrite
                       4096
                                                            77625 95213
                                                                                                    98947
                                                                                                                      134874
                                                                                                                                           191268
                                                                                                                                                                126725
                                                                                                                                                                                    147411
                                                                                                                                                                                                           146978
ozone test complete
                                                                                                                                                                                               record
                                                                                                                                                                                                                      stride
                  kB reclen
4096 32
                                                     write rewrite
94293 93809
                                                                                                                                                     write
129929
                                                                                                                                                                                                                                         fwrite frewrite
                                                                                                                                                                                                                                                                                  fread freread
                                                                                            read reread read
92324 210755 211307
                                                                                                                                                                         read
187561
                                                                                                                                                                                             rewrite
158037
                                                                                                                                                                                                                         read
one test complete.
```

Wirte	Rewrite	Read	Reread	Randomread	Randomwrite	Bkwdread	Record
							rewrite
88005	94061	101570	164765	205791	128917	169608	155267

## CFQ scheduler 옵션값(평균값) table

Byte	Wirte	Rewrite	Read	Reread	Randomread	Randomwrite	Bkwdread	Record
								rewrite
4kb	23044	22030	23604	25770	25809	24817	24667	23665
8kb	39334	40009	48954	52982	55283	51176	56812	48847
16kb	61521	62560	74441	92620	99728	99405	105545	79173
32kb	88005	94061	101570	164765	205791	128917	169608	155267

## Noop scheduler의 옵션 결과값(평균값)table

Byte	Wirte	Rewrite	Read	Reread	Randomread	Randomwrite	Bkwdread	Record
								rewrite
4kb	26434	27456	28808	28014	22877	22908	20185	19964
8kb	46270	55336	57455	58902	52540	52965	50043	42112
16kb	76480	96537	89929	99062	97685	97807	92480	98854
32kb	138223	158777	203610	189460	198244	192366	197143	203857

# Deadline scheduler 옵션값(평균값) table

Byte	Wirte	Rewrite	Read	Reread	Randomread	Randomwrite	Bkwdread	Record
								rewrite
4kb	27370	29471	29999	31128	28016	27945	28830	28914
8kb	50345	57480	56918	56767	53131	54865	55781	54115
16kb	96777	117689	119432	126191	108405	108010	118948	102634
32kb	131590	172884	217462	200962	178663	211876	208897	199757

# CFQ scheduler 옵션값(평균값) table

Byte	Wirte	Rewrite	Read	Reread	Randomread	Randomwrite	Bkwdread	Record
								rewrite
4kb	23044	22030	23604	25770	25809	24817	24667	23665
8kb	39334	40009	48954	52982	55283	51176	56812	48847
16kb	61521	62560	74441	92620	99728	99405	105545	79173
32kb	88005	94061	101570	164765	205791	128917	169608	155267

# 위의 정리된 table을 참고하여서 아래 옵션값들을 각각의 schedule별로 값을 비교하면 Sequential write값을 비교

Byte	NOOP	DEADLINE	CFQ
4kb	26434	27370	23044
8kb	46270	50345	39334
16kb	76480	96777	61521
32kb	138223	131590	88005

ouput값은 kbytes/sec이며, 전체적으로 생각했을 때 Sequential write는 DEADLINE>NOOP>CFQ값이므로 앞의 순서대로 성능이 좋다고 예측할 수 있습니다.

# Sequential read값을 비교

Byte	NOOP	DEADLINE	CFQ
4kb	28808	29999	23604
8kb	57455	56918	48954
16kb	89929	119432	74441
32kb	203610	217462	101570

Sequential write와 같이 sequential read값도 전체적으로 생각하면 DEADLINE>NOOP>CFQ값이므

로 앞의 순서대로 성능이 좋다고 예측할 수 있습니다.

#### Random r/w값을 비교

#### ->random read

Byte	NOOP	DEADLINE	CFQ
4kb	22877	28016	25809
8kb	52540	53131	55283
16kb	97685	108405	99728
32kb	198244	178663	205791

4kb~16kb까지는 DEADLINE>CFQ>NOOP이므로 이 순서대로 성능이 좋다고 예측할 수 있고, 32kb는 CFQ>NOOP>DEADLINE이므로 이 순서로 성능이 좋다고 예측할 수 있습니다.

#### ->random write

Byte	NOOP	DEADLINE	CFQ
4kb	22908	27945	24817
8kb	52965	54865	51176
16kb	97807	108010	99405
32kb	192366	211876	128917

8kb에서는 DEADLINE>NOOP>CFQ순이지만 오차를 고려하면 Random read와 비슷하게 4kb~16kb까지는 DEADLINE>CFQ>NOOP이므로 이 순서대로 성능이 좋다고 예측할 수 있고, 32kb는 CFQ>NOOP>DEADLINE이므로 이 순서로 성능이 좋다고 예측할 수 있습니다.

## Bkwd read 값을 비교

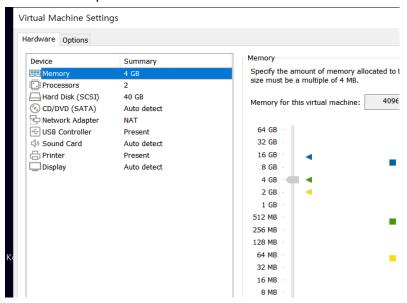
Byte	NOOP	DEADLINE	CFQ
4kb	20185	28830	24667
8kb	50043	55781	56812
16kb	92480	118948	105545
32kb	197143	208897	169608

Bkwd read값은 4kb~16kb까지는 DEADLINE>CFQ>NOOP이므로 이 순서대로 성능이 좋다고 예측할 수 있고, 32kb는 CFQ>NOOP>DEADLINE이므로 이 순서로 성능이 좋다고 예측할 수 있습니다 Record rewrite값을 비교

Byte	NOOP	DEADLINE	CFQ
4kb	19964	28914	23665
8kb	42112	54115	48847
16kb	98854	102634	79173
32kb	203857	199757	155267

Record rewrite값은 4kb~8kb까지는 DEADLINE>CFQ>NOOP이므로 이 순서대로 성능이 좋다고 예측할 수 있고, 16kb~32kb는 CFQ>NOOP>DEADLINE이므로 이 순서로 성능이 좋다고 예측할 수 있습니다.

# <hardware spec>



CPU즉 processors는 2이며, HDD harddisk는 40GB, memory는 4GB입니다.

## <reference>

광운대학교/운영체제실습 15주차 강의자료

옵션값

//https://m.blog.naver.com/PostView.naver?isHttpsRedirect=true&blogId=nanong7&logNo=2020 7265849

i/o zone

https://duksoo.tistory.com/entry/IOzone-%EC%9D%84-%EC%9D%B4%EC%9A%A9%ED%95%9C-Disk-%EC%84%B1%EB%8A%A5-%EC%B8%A1%EC%A0%95%EB%B2%95