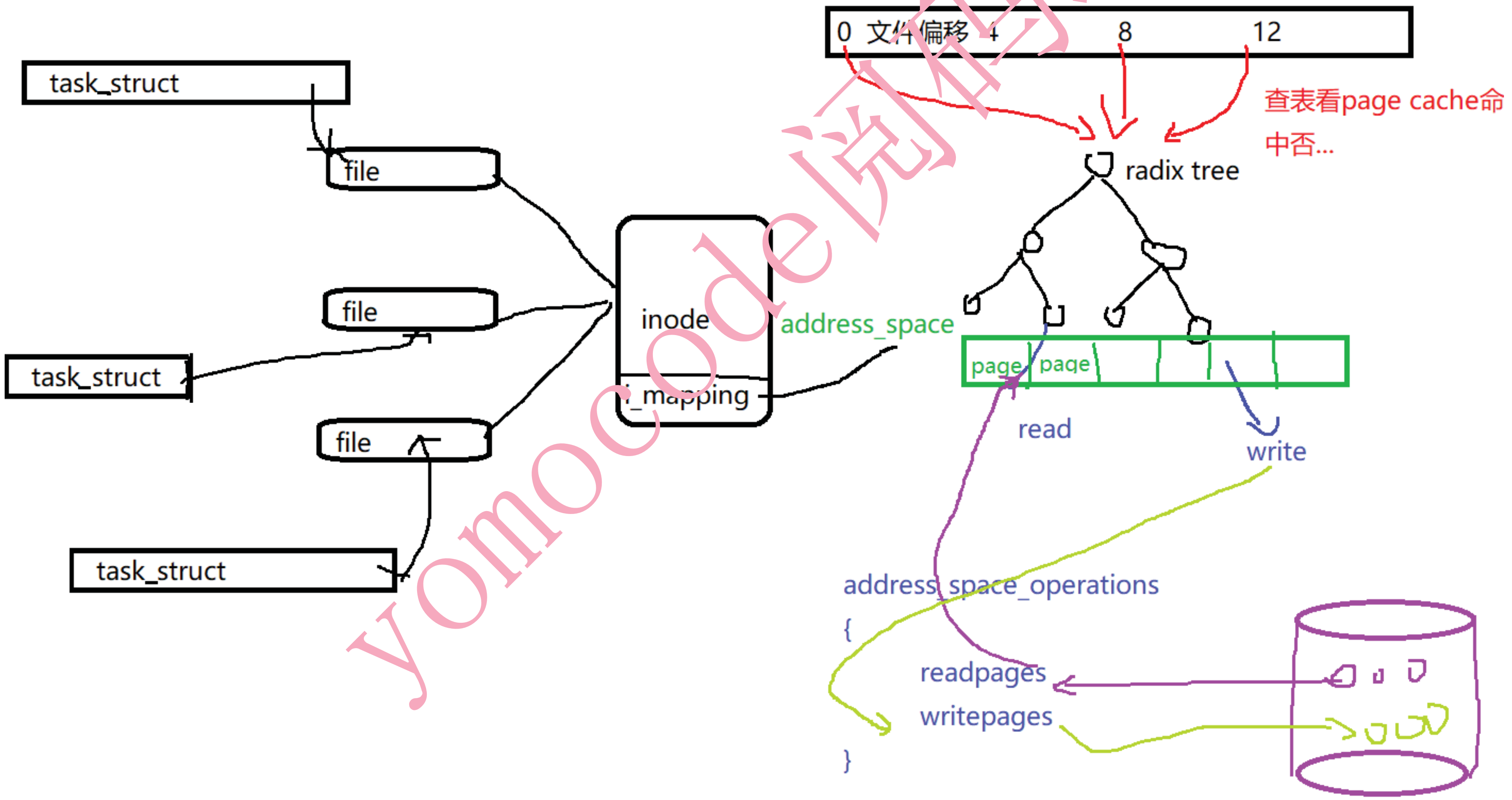
Linux铁三角之I/O(四)

麦当劳喜欢您来，喜欢您再来

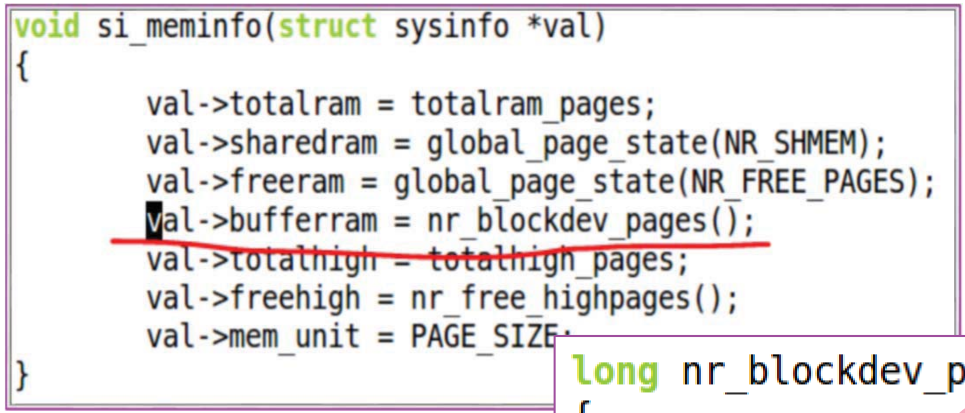
块I/O流 程 与I/O调 度 器

*一个块IO的一生：从page cache到bio到request
*O_DIRECT和O_SYNC
*blktrace
*IO调度和CFQ调度算法
*CFQ和ionice
*cgroup与IO
*io性能调试：iotop, iostat

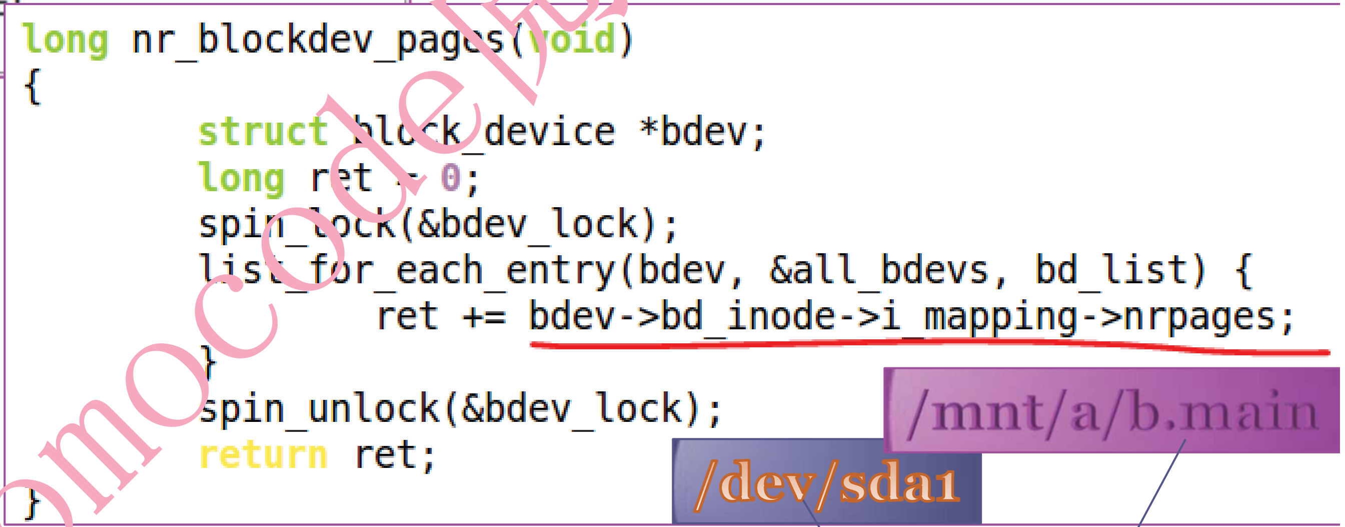
file到address_space_operations



i_mapping决 定 是buffers还 是cached



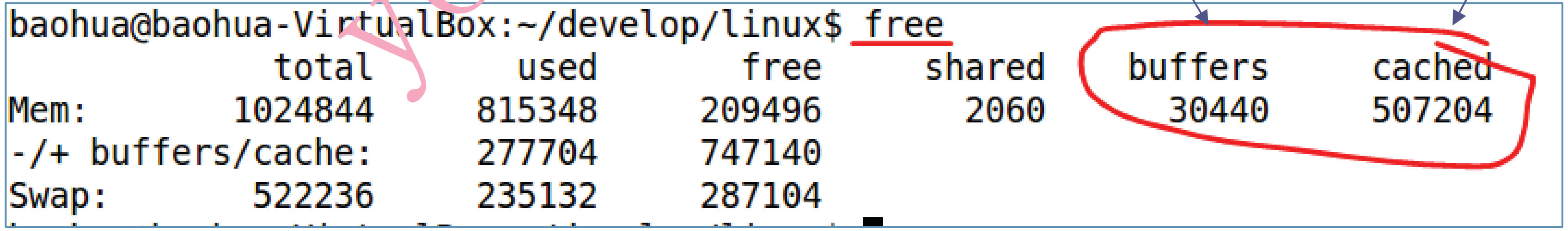
```
void si_meminfo(struct sysinfo *val)
{
        val->totalram = totalram_pages;
        val->sharedram = global_page_state(NR_SHMEM);
        val->freeram = global_page_state(NR_FREE_PAGES);
        val->bufferram = nr_blockdev_pages();
        val->totalhigh = totalhigh_pages;
        val->freehigh = nr_free_highpages();
        val->mem_unit = PAGE_SIZE;
}
```



```
long nr_blockdev_pages(void)
{
        struct block_device *bdev;
        long ret = 0;
        spin_lock(&bdev_lock);
        list_for_each_entry(bdev, &all_bdevs, bd_list) {
                ret += bdev->bd_inode->i_mapping->nrpages;
        }
        spin_unlock(&bdev_lock);
        return ret;
}
```

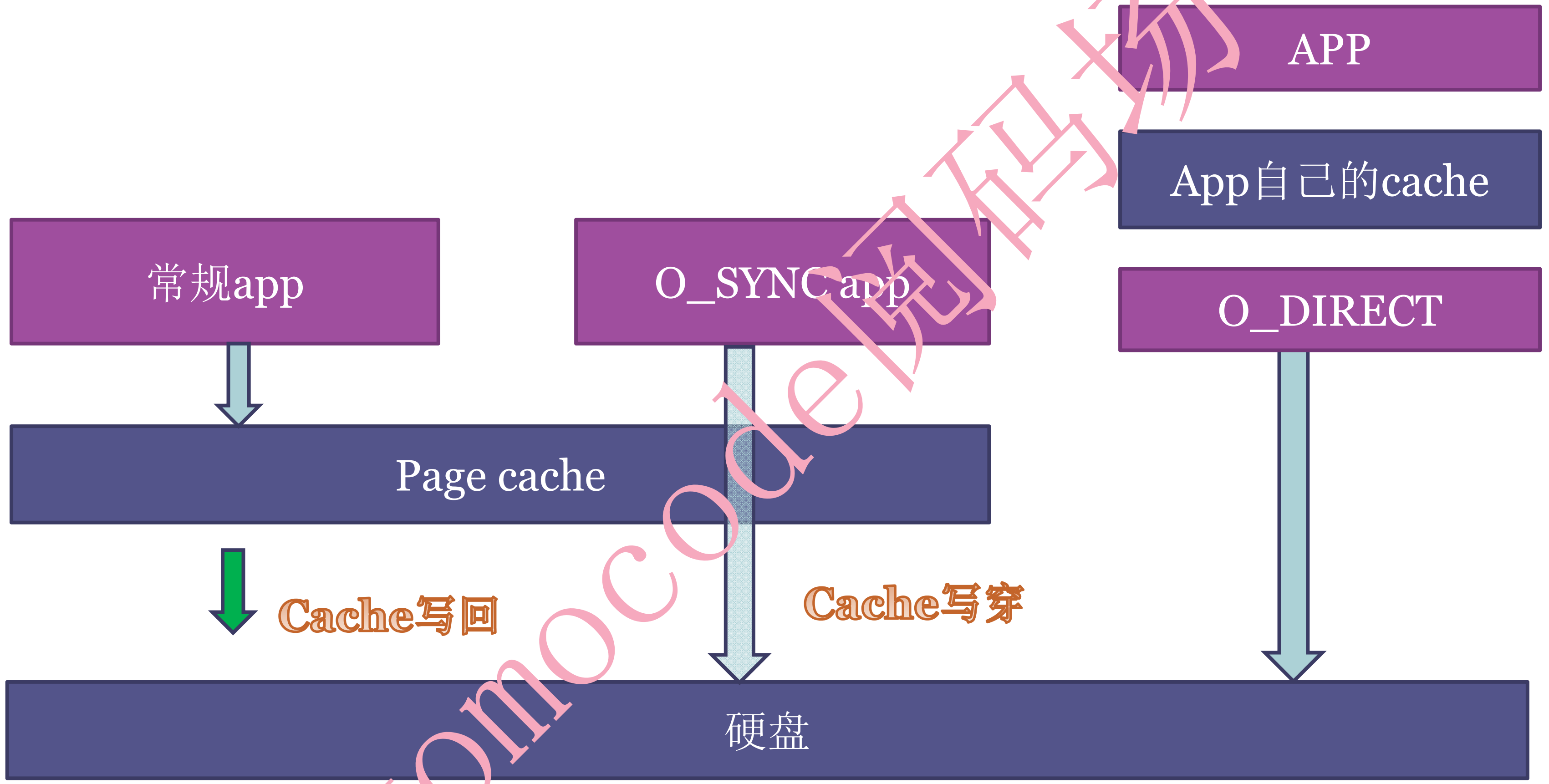
/mnt/a/b.main

/dev/sda1



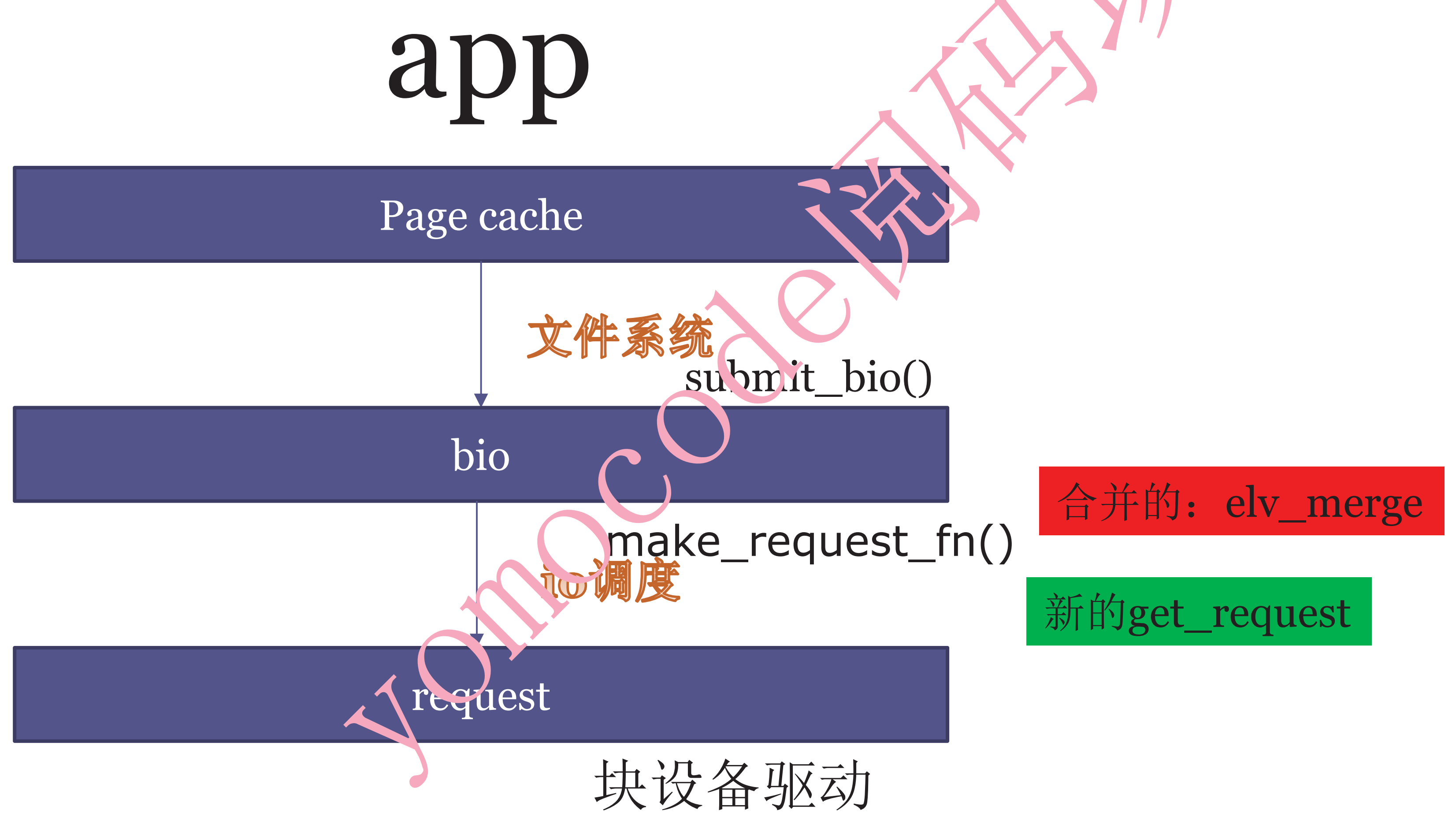
```
baohua@baohua-VirtualBox:~/develop/linux$ free
             total       used       free     shared    buffers     cached
Mem:       1024844     815348     209496       2060      30440     507204
-/+ buffers/cache:     277704     747140
Swap:       522236     235132     287104
```

O_DIRECT和O_SYNC

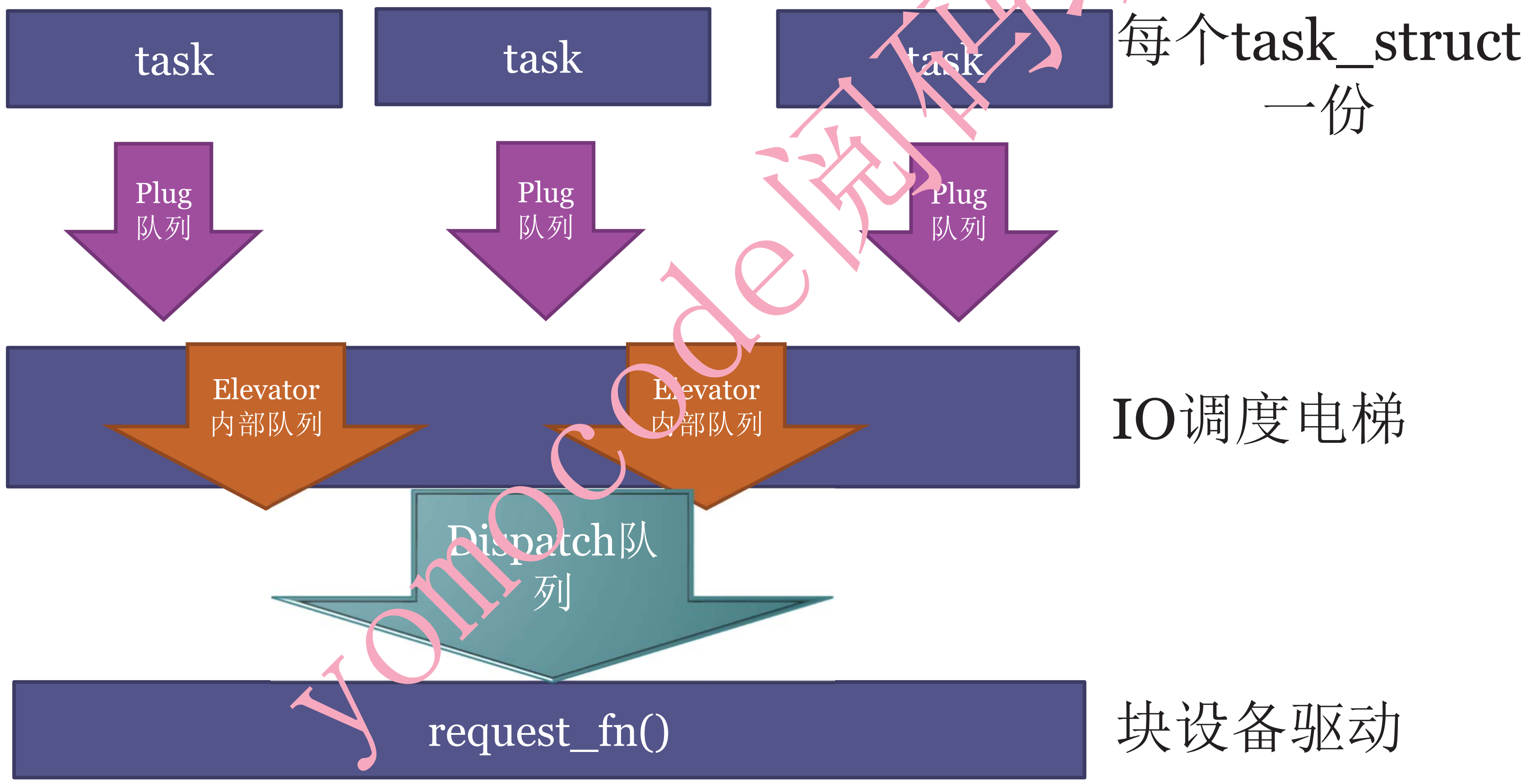


"The thing that has always disturbed me about O_DIRECT is that the whole interface is just stupid, and was probably designed by a deranged monkey on some serious mind-controlling substances."—Linus

Block IO流 程


app
Page cache
文件系统
submit_bio()
bio
make_request_fn()
io调度
request
块设备驱动
合并的：elv_merge
新的get_request

Request的三个队列



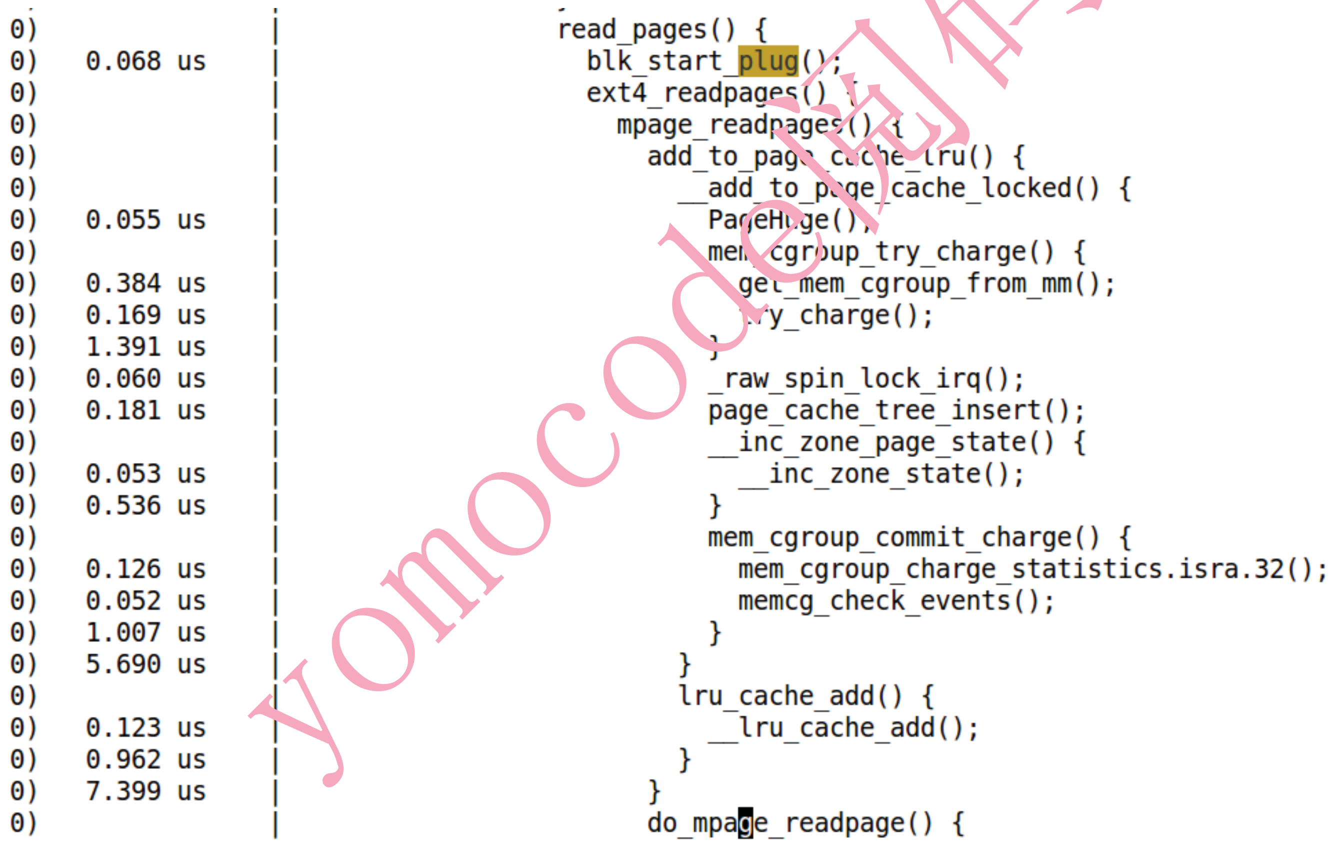
读写流程的ftrace

```
#include <unistd.h>
#include <fcntl.h>

main()
{
        int fd;
        char buf[4096];

        sleep(30); //run ./funtion.sh to trace this process
        fd = open("file", O_RDONLY);
        read(fd, buf, 4096);
        read(fd, buf, 4096);
}
```

```
#!/bin/bash

debugfs=/sys/kernel/debug
echo nop > $debugfs/tracing/current_tracer
echo 0 > $debugfs/tracing/tracing_on
echo `pidof read` > $debugfs/tracing/set_ftrace_pid
echo function_graph > $debugfs/tracing/current_tracer
echo vfs_read > $debugfs/tracing/set_graph_function
echo 1 > $debugfs/tracing/tracing_on
```

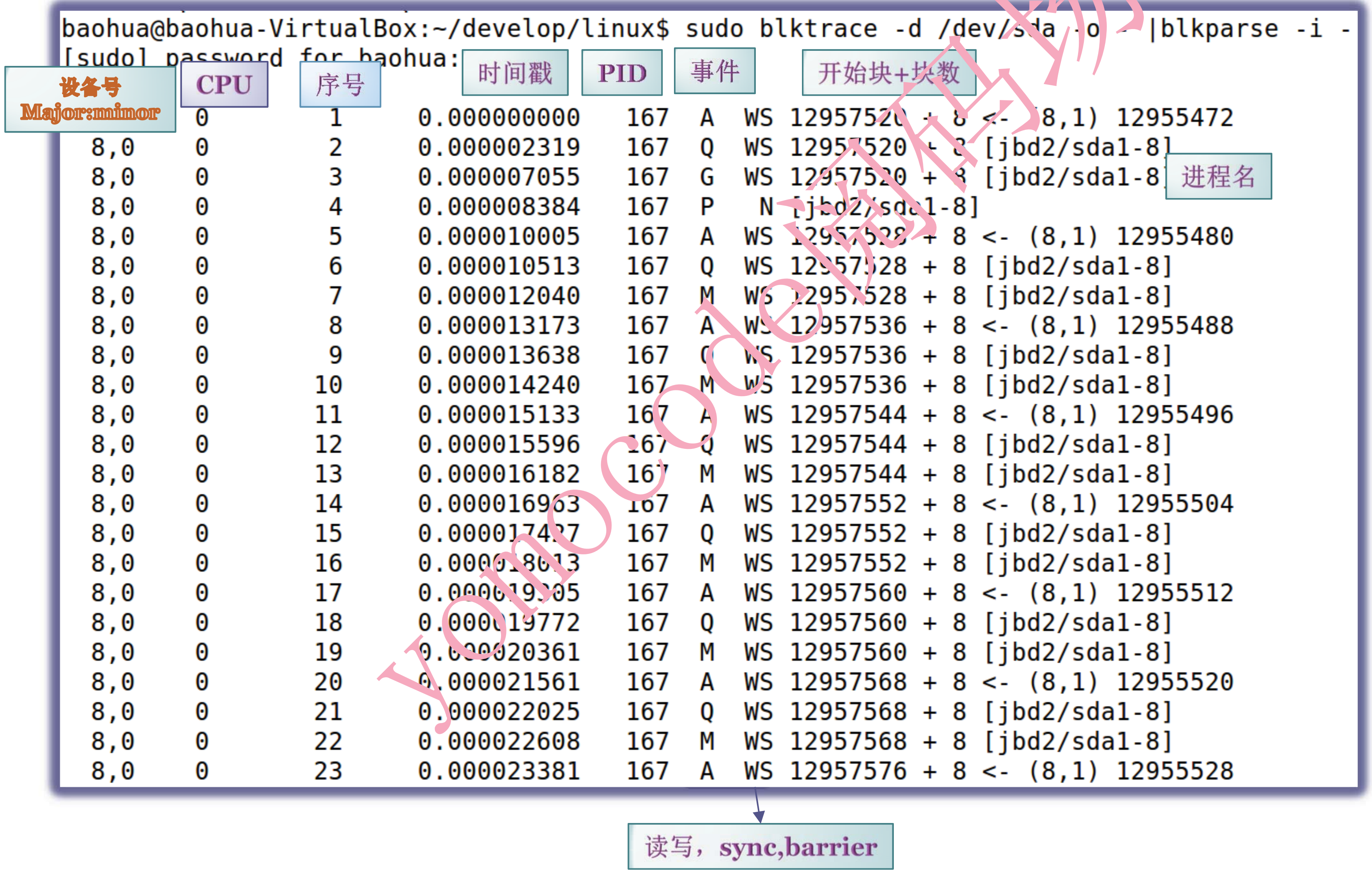
查看ftrace结果

- # cat /sys/kernel/debug/tracing/trace



```
0)                 |                  read_pages() {
0)   0.068 us      |                    blk_start_plug();
0)                 |                    ext4_readpages() {
0)                 |                      mpage_readpages() {
0)                 |                        add_to_page_cache_lru() {
0)                 |                          __add_to_page_cache_locked() {
0)   0.055 us      |                            PageHuge();
0)                 |                            mem_cgroup_try_charge() {
0)   0.384 us      |                              get_mem_cgroup_from_mm();
0)   0.169 us      |                              try_charge();
0)   1.391 us      |                            }
0)   0.060 us      |                            _raw_spin_lock_irq();
0)   0.181 us      |                            page_cache_tree_insert();
0)                 |                            __inc_zone_page_state() {
0)   0.053 us      |                              __inc_zone_state();
0)   0.536 us      |                            }
0)                 |                            mem_cgroup_commit_charge() {
0)   0.126 us      |                              mem_cgroup_charge_statistics.isra.32();
0)   0.052 us      |                              memcg_check_events();
0)   1.007 us      |                            }
0)   5.690 us      |                          }
0)                 |                          lru_cache_add() {
0)   0.123 us      |                            __lru_cache_add();
0)   0.962 us      |                          }
0)   7.399 us      |                        }
0)                 |                        do_mpage_readpage() {
```

blktrace



```
baohua@baohua-VirtualBox:~/develop/linux$ sudo blktrace -d /dev/sda -o - |blkparse -i -
[sudo] password for baohua:
  8,0    0        1     0.000000000   167  A  WS 12957520 + 8 <- (8,1) 12955472
  8,0    0        2     0.000002319   167  Q  WS 12957520 + 8 [jbd2/sda1-8]
  8,0    0        3     0.000007055   167  G  WS 12957520 + 8 [jbd2/sda1-8]
  8,0    0        4     0.000008384   167  P   N [jbd2/sda1-8]
  8,0    0        5     0.000010005   167  A  WS 12957528 + 8 <- (8,1) 12955480
  8,0    0        6     0.000010513   167  Q  WS 12957528 + 8 [jbd2/sda1-8]
  8,0    0        7     0.000012040   167  M  WS 12957528 + 8 [jbd2/sda1-8]
  8,0    0        8     0.000013173   167  A  WS 12957536 + 8 <- (8,1) 12955488
  8,0    0        9     0.000013638   167  Q  WS 12957536 + 8 [jbd2/sda1-8]
  8,0    0       10     0.000014240   167  M  WS 12957536 + 8 [jbd2/sda1-8]
  8,0    0       11     0.000015133   167  A  WS 12957544 + 8 <- (8,1) 12955496
  8,0    0       12     0.000015596   167  Q  WS 12957544 + 8 [jbd2/sda1-8]
  8,0    0       13     0.000016182   167  M  WS 12957544 + 8 [jbd2/sda1-8]
  8,0    0       14     0.000016963   167  A  WS 12957552 + 8 <- (8,1) 12955504
  8,0    0       15     0.000017427   167  Q  WS 12957552 + 8 [jbd2/sda1-8]
  8,0    0       16     0.000018013   167  M  WS 12957552 + 8 [jbd2/sda1-8]
  8,0    0       17     0.000019305   167  A  WS 12957560 + 8 <- (8,1) 12955512
  8,0    0       18     0.000019772   167  Q  WS 12957560 + 8 [jbd2/sda1-8]
  8,0    0       19     0.000020361   167  M  WS 12957560 + 8 [jbd2/sda1-8]
  8,0    0       20     0.000021561   167  A  WS 12957568 + 8 <- (8,1) 12955520
  8,0    0       21     0.000022025   167  Q  WS 12957568 + 8 [jbd2/sda1-8]
  8,0    0       22     0.000022608   167  M  WS 12957568 + 8 [jbd2/sda1-8]
  8,0    0       23     0.000023381   167  A  WS 12957576 + 8 <- (8,1) 12955528
```

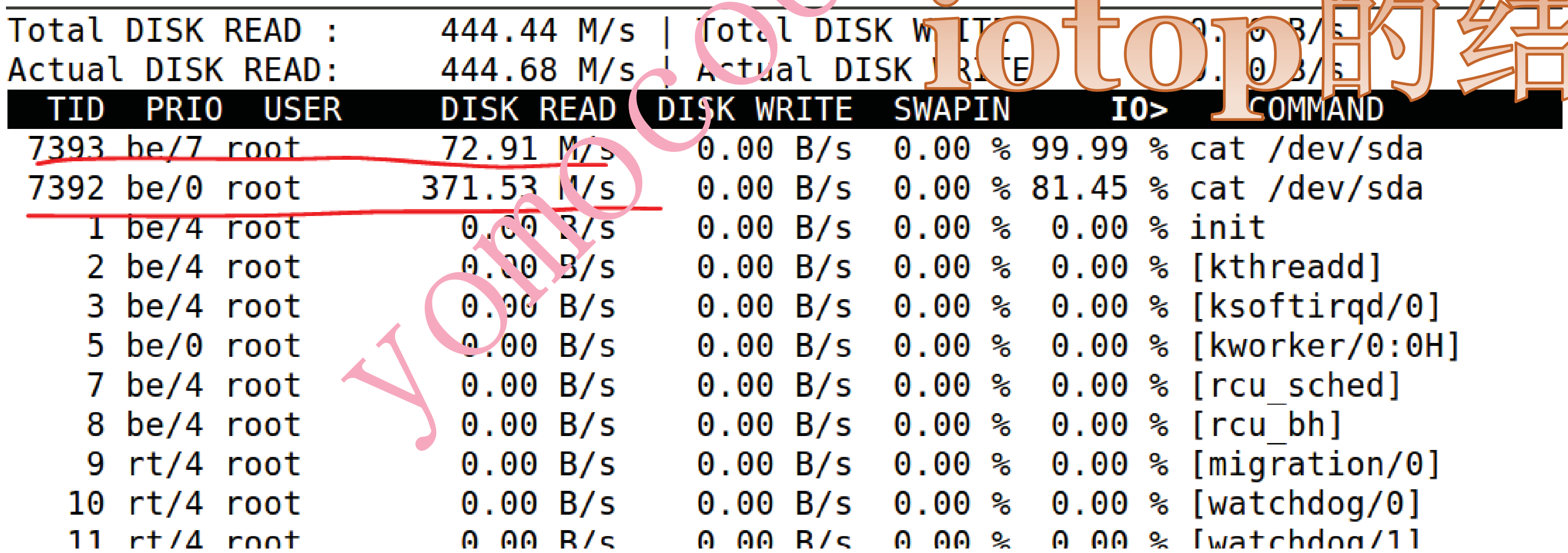
IO调度算法

```
baohua@baohua-VirtualBox:/sys/block/sda/queue$ cat scheduler
noop [deadline] cfq
```

- ✓ Noop：最简单的调度器，把邻近bio进行了合并处理。
- ✓ Deadline: 保证读优先的前提下，写不会饿死。
- ✓ CFQ: 考虑进程。

CFQ和ionice

```
root@baohua-VirtualBox:/sys/block/sda/queue# echo cfq > scheduler

# ionice -c 2 -n 0 cat /dev/sda > /dev/null&
[1] 7392
# ionice -c 2 -n 7 cat /dev/sda > /dev/null&
[2] 7393
```



```
Total DISK READ :      444.44 M/s | Total DISK WRITE :       0.00 B/s
Actual DISK READ:      444.68 M/s | Actual DISK WRITE:       0.00 B/s
  TID  PRIO  USER     DISK READ  DISK WRITE  SWAPIN     IO>    COMMAND
 7393 be/7 root      72.91 M/s    0.00 B/s  0.00 % 99.99 % cat /dev/sda
 7392 be/0 root     371.53 M/s    0.00 B/s  0.00 % 81.45 % cat /dev/sda
    1 be/4 root       0.00 B/s    0.00 B/s  0.00 %  0.00 % init
    2 be/4 root       0.00 B/s    0.00 B/s  0.00 %  0.00 % [kthreadd]
    3 be/4 root       0.00 B/s    0.00 B/s  0.00 %  0.00 % [ksoftirqd/0]
    5 be/0 root       0.00 B/s    0.00 B/s  0.00 %  0.00 % [kworker/0:0H]
    7 be/4 root       0.00 B/s    0.00 B/s  0.00 %  0.00 % [rcu_sched]
    8 be/4 root       0.00 B/s    0.00 B/s  0.00 %  0.00 % [rcu_bh]
    9 rt/4 root       0.00 B/s    0.00 B/s  0.00 %  0.00 % [migration/0]
   10 rt/4 root       0.00 B/s    0.00 B/s  0.00 %  0.00 % [watchdog/0]
   11 rt/4 root       0.00 B/s    0.00 B/s  0.00 %  0.00 % [watchdog/1]
```

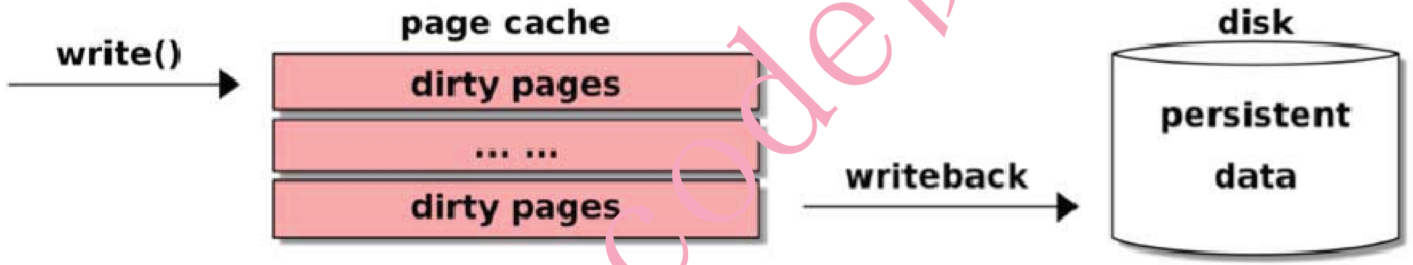
iotop的结果

至于cgroup的weight和throttle

```
mkdir -p /sys/fs/cgroup/blkio/A/ /sys/fs/cgroup/blkio/B

cgexec -g blkio:A dd if=/dev/sda of=/dev/null &
cgexec -g blkio:B dd if=/dev/sda of=/dev/null &


cgexec -g blkio:A dd if=/dev/zero of=/mnt/a oflag=direct bs=1M count=300
&

echo "8:0  1048576" >
/sys/fs/cgroup/blkio/A/blkio.throttle.read_bps_device
echo "8:0  1048576" >
/sys/fs/cgroup/blkio/A/blkio.throttle.write_bps_device
```

Cgroup v2的writeback throttle

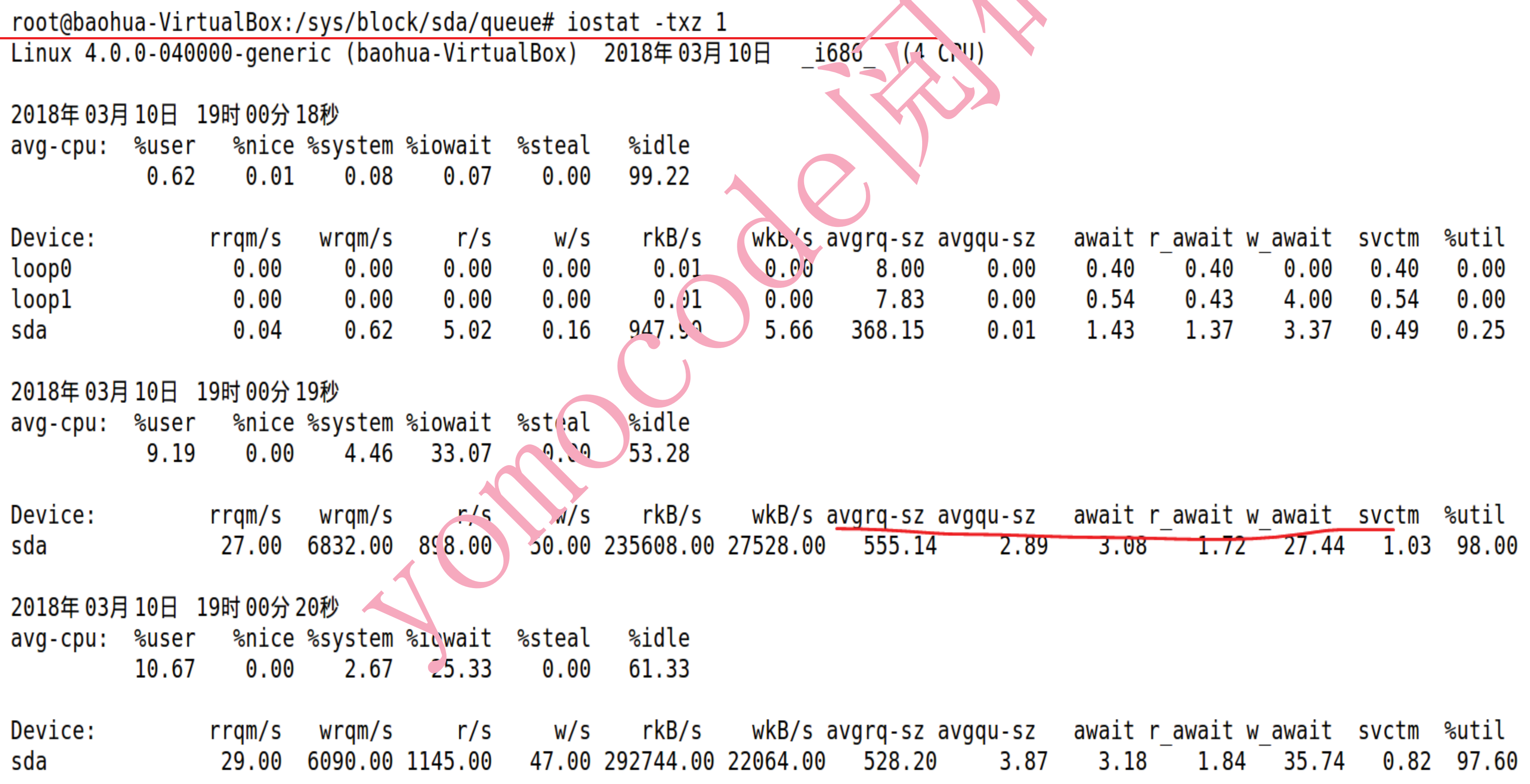
在Cgroup v1里面，blkio cgroup的写只能用于DIRECT_IO的场景(writeback的线程和写的不是一个线程)。
这使得write变成了“system wide”而不是group wide



在Cgroup v2里面，打通了memory group和blkio group，能知晓每个group的dirty情况。

iostat

```
# ionice -c 2 -n 0 cat /dev/sda > /dev/null&
# ionice -c 2 -n 7 cat /dev/sda > /dev/null&
```



```
root@baohua-VirtualBox:/sys/block/sda/queue# iostat -txz 1
Linux 4.0.0-040000-generic (baohua-VirtualBox)  2018年03月10日  _i686_  (4 CPU)

2018年03月10日 19时00分18秒
avg-cpu:  %user   %nice %system %iowait  %steal   %idle
           0.62    0.01    0.08    0.07    0.00   99.22

Device:         rrqm/s   wrqm/s     r/s     w/s    rkB/s    wkB/s avgrq-sz avgqu-sz   await r_await w_await  svctm  %util
loop0             0.00     0.00    0.00    0.00     0.01     0.00     8.00     0.00    0.40    0.40    0.00   0.40   0.00
loop1             0.00     0.00    0.00    0.00     0.01     0.00     7.83     0.00    0.54    0.43    4.00   0.54   0.00
sda               0.04     0.62    5.02    0.16   947.90     5.66   368.15     0.01    1.43    1.37    3.37   0.49   0.25

2018年03月10日 19时00分19秒
avg-cpu:  %user   %nice %system %iowait  %steal   %idle
           9.19    0.00    4.46   33.07    0.00   53.28

Device:         rrqm/s   wrqm/s     r/s     w/s    rkB/s    wkB/s avgrq-sz avgqu-sz   await r_await w_await  svctm  %util
sda              27.00  6832.00  898.00   50.00 235608.00 27528.00   555.14     2.89    3.08    1.72   27.44   1.03  98.00

2018年03月10日 19时00分20秒
avg-cpu:  %user   %nice %system %iowait  %steal   %idle
          10.67    0.00    2.67   25.33    0.00   61.33

Device:         rrqm/s   wrqm/s     r/s     w/s    rkB/s    wkB/s avgrq-sz avgqu-sz   await r_await w_await  svctm  %util
sda              29.00  6090.00 1145.00   47.00 292744.00 22064.00   528.20     3.87    3.18    1.84   35.74   0.82  97.60
```

谢 谢！