Monitoring IO performance using iostat & pt-diskstats

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About Me

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Why Pythian?

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- **Global Reach & Scalability:**
  - Around the clock global remote support for DBA and consulting, systems administration, special projects or emergency response

Why the interest in IO monitoring?

```
Latency Comparison Numbers
--------------------------
L1 cache reference                           0.5 ns
Branch mispredict                            5   ns
L2 cache reference                           7   ns              14x L1 cache
Mutex lock/unlock                           25   ns
Main memory reference                      100   ns              20x L2 cache, 200x L1 cache
Compress 1K bytes with Zippy             3,000   ns
Send 1K bytes over 1 Gbps network       10,000   ns    0.01 ms
Read 4K randomly from SSD*             150,000   ns    0.15 ms
Read 1 MB sequentially from memory     250,000   ns    0.25 ms
Round trip within same datacenter      500,000   ns    0.5  ms
Read 1 MB sequentially from SSD*     1,000,000   ns    1    ms  4X memory
Disk seek                           10,000,000   ns   10    ms  20x datacenter roundtrip
Read 1 MB sequentially from disk    20,000,000   ns   20    ms  80x memory, 20X SSD
Send packet CA->Netherlands->CA    150,000,000   ns  150    ms
 * Assuming ~1GB/sec SSD

Credit
------
By Jeff Dean:               http://research.google.com/people/jeff/
Originally by Peter Norvig: http://norvig.com/21-days.html#answers
```

(https://gist.github.com/jboner/2841832)

Monitoring IO on Linux

- There are a number of tools available to monitor IO on Linux. This presentation looks at two tools, iostat and pt-diskstats. These tools look to provide an overview of block devices iops, throughput and latency.
- You can dive deeper:
  - Tools such as iotop and atop can be used to expose process level IO performance by gathering data from /proc/[process]/io.
  - blktrace can be used with blkparse, either independently or by using btrace. Output can also be analysed using seekwatcher.
  - Tools such as bonnie/bonnie++, iometer, iozone, and ORION can be used to benchmark a block device.

iostat

- iostat is part of the sysstat utilities which is maintained by Sebastien Godard.
- sysstat is open source software written in C, and is available under the GNU General Public License, version 2.
- Other utilities in the sysstat package include mpstat, pidstat, sar, nfsiostat, and cifsiostat.
- sysstat is likely available from your favourite repo, but the latest version can be found here:

  http://sebastien.godard.pagesperso-orange.fr/download.html
- If you have an old (or very old) version installed, it is recommended you install the latest stable version.

iostat

- At the time of writing the current stable version is 10.0.5.
- Note version 10 removes support for kernels older than 2.6.
- The version you have installed can be found with -V option.

```
[ben@lab ~]$ iostat -V
sysstat version 10.0.3
(C) Sebastien Godard (sysstat <at> orange.fr)
```

iostat

- By default iostat produces two reports; the CPU Utilization report and the Device Utilization report.
- The default invocation shows the statistics since system start up.

```
[ben@lab ~]$ iostat
Linux 3.8.4-102.fc17.x86_64 (lab.mysqlhome)   04/10/2013     _x86_64_  (2 CPU)

avg-cpu:  %user   %nice %system %iowait  %steal   %idle
          17.56    2.93    3.62    2.42    0.00   73.47

Device:            tps    kB_read/s    kB_wrtn/s    kB_read    kB_wrtn
sda               8.51       100.17        44.62     890987     396917
dm-0              4.87        78.76         6.80     700565      60488
dm-1              7.40        20.74        37.45     184505     333128
dm-2              0.14         0.19         0.37       1693       3300
```

iostat

- Inclusion of the CPU and Device Utilization reports can be controlled with the -c and -d options.
- The Network Filesystem report (-n) was deprecated in version 10 and replaced with the nfsiostat and cifsiostat utilities.

```
[ben@lab ~]$ iostat -c
Linux 3.8.4-102.fc17.x86_64 (lab.mysqlhome)   04/10/2013     _x86_64_  (2 CPU)

avg-cpu:  %user   %nice %system %iowait  %steal   %idle
          17.01    2.66    3.69    2.35    0.00   74.29

[ben@lab ~]$ iostat -d
Linux 3.8.4-102.fc17.x86_64 (lab.mysqlhome)   04/10/2013     _x86_64_  (2 CPU)

Device:            tps    kB_read/s    kB_wrtn/s    kB_read    kB_wrtn
sda               8.28        94.60        45.60     926915     446773
dm-0              4.65        75.00         6.34     734861      62104
dm-1              7.28        19.00        38.75     186129     379644
dm-2              0.15         0.17         0.51       1701       5024
```

iostat

- The default Device Utilization report can be replaced with extended statistics using the -x option.

```
[ben@lab ~]$ iostat -cx  |  [ben@lab ~]$ iostat -x
Linux 3.8.4-102.fc17.x86_64 (lab.mysqlhome)    04/10/2013     _x86_64_       (2 CPU)

avg-cpu:  %user   %nice %system %iowait  %steal   %idle
          16.23    2.27    3.67    2.20    0.00   75.63

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               1.34     2.67    3.33    4.39    81.15    45.44    32.81     0.51   66.41   29.59   94.30   7.77   6.00
dm-0              0.00     0.00    3.24    0.82    64.10     5.72    34.38     0.37   91.29   35.84  309.17   4.94   2.01
dm-1              0.00     0.00    1.34    5.77    16.54    39.14    15.66     0.31   43.20   32.95   45.59   6.42   4.56
dm-2              0.00     0.00    0.05    0.10     0.15     0.58     9.56     0.01   68.81   26.96   89.14  16.18   0.25

[ben@lab ~]$ iostat -dx
Linux 3.8.4-102.fc17.x86_64 (lab.mysqlhome)    04/10/2013     _x86_64_       (2 CPU)

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               1.34     2.67    3.32    4.39    81.09    45.42    32.80     0.51   66.40   29.59   94.27   7.77   6.00
dm-0              0.00     0.00    3.24    0.82    64.05     5.71    34.38     0.37   91.29   35.84  309.17   4.94   2.00
dm-1              0.00     0.00    1.34    5.77    16.53    39.12    15.66     0.31   43.20   32.95   45.58   6.42   4.56
dm-2              0.00     0.00    0.05    0.10     0.15     0.58     9.56     0.01   68.75   26.96   89.00  16.21   0.25
```

iostat

- Whilst reviewing the stats since since system start up can be useful, more often you will want to review current activity.
- Current activity can be displayed by specifying an *interval* measured in seconds.
- Output will continue until interrupted or a specified *count* has been reached.

```
[ben@lab ~]$ iostat -dx [interval] [count]
```

```
[ben@lab ~]$ iostat -dx 3
```

The above command will display extended device statistics since system start up in the first report, and the deltas for the last 3 seconds in subsequent reports until interrupted.

```
[ben@lab ~]$ iostat -dx 3 3
```

The above command will display extended device statistics since system start up in the first report, and the deltas for the last 3 seconds in two further reports.

iostat

```
[ben@lab ~]$ iostat -dx 3 3
Linux 3.8.4-102.fc17.x86_64 (lab.mysqlhome)    04/10/2013     _x86_64_       (2 CPU)

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               1.16     2.66    2.89    4.27    70.37    44.66    32.10     0.46   64.37   29.55   87.96   7.94   5.69
dm-0              0.00     0.00    2.80    0.78    55.53     5.23    33.94     0.32   90.12   35.83  286.38   5.03   1.80
dm-1              0.00     0.00    1.17    5.68    14.39    38.73    15.50     0.29   42.12   32.81   44.05   6.38   4.37
dm-2              0.00     0.00    0.04    0.11     0.13     0.70    10.68     0.01   63.30   26.96   77.34  15.47   0.24

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               0.00     4.67    0.00    1.00     0.00    21.33    42.67     0.02   23.33    0.00   23.33  23.33   2.33
dm-0              0.00     0.00    0.00    0.00     0.00     0.00     0.00     0.00    0.00    0.00    0.00   0.00   0.00
dm-1              0.00     0.00    0.00    5.33     0.00    21.33     8.00     0.03    5.25    0.00    5.25   4.38   2.33
dm-2              0.00     0.00    0.00    0.00     0.00     0.00     0.00     0.00    0.00    0.00    0.00   0.00   0.00

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               0.00     1.67    0.00    9.00     0.00    41.33     9.19     0.45   50.44    0.00   50.44   6.52   5.87
dm-0              0.00     0.00    0.00    0.00     0.00     0.00     0.00     0.00    0.00    0.00    0.00   0.00   0.00
dm-1              0.00     0.00    0.00    8.33     0.00    33.33     8.00     0.46   54.92    0.00   54.92   2.52   2.10
dm-2              0.00     0.00    0.00    2.00     0.00     8.00     8.00     0.09   45.50    0.00   45.50  18.83   3.77
```

iostat

- Since version 7.1.3 the report can be made more readable by including the registered device mapper names using the -N option.
- Using the -N can skew the columns on each line, so it can be useful to also specify the -h option to keep the report easily readable.
- Adding -k or -m will specify kB / mB per second respectively.

  (If the POSIXLY_CORRECT environment variable is NULL the data read / written is displayed in kB by default)
- Adding the -t option will include a timestamp with each report.
- Adding the -z option will exclude any inactive devices from the individual reports.
- In version 10.1.3 (currently development version), adding the -y option suppresses the first report showing statistics since system start up.

iostat

```
[ben@lab ~]$ iostat -dxNhtz 3 2
Linux 3.8.4-102.fc17.x86_64 (lab.mysqlhome)    04/10/2013     _x86_64_       (2 CPU)

04/10/2013 11:37:08 AM
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
                  1.07     2.63    2.67    4.17    65.04    43.60    31.76     0.43   63.17   29.54   84.72   8.06   5.52
vg_proddba-lv_root
                  0.00     0.00    2.59    0.74    51.36     4.94    33.80     0.30   89.51   35.81  276.28   5.09   1.70
vg_proddba-lv_home
                  0.00     0.00    1.08    5.58    13.27    37.93    15.36     0.28   41.32   32.82   42.97   6.39   4.26
vg_proddba-lv_tmp
                  0.00     0.00    0.04    0.11     0.12     0.73    11.04     0.01   60.84   26.96   72.70  15.28   0.23

04/10/2013 11:37:11 AM
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
                  0.00     3.33    0.00    3.33     0.00    34.67    20.80     0.09   28.10    0.00   28.10  16.70   5.57
vg_proddba-lv_home
                  0.00     0.00    0.00    6.00     0.00    34.67    11.56     0.10   16.00    0.00   16.00   9.28   5.57
```

-t (timestamp reported with sample)

-z (report only includes active devices for this sample)

-N (registered device mapper name)

-h (columns stay aligned even with long device names)

iostat

- In version 10.0.5, the devices in the Device Utilization can be grouped using the -g option.
- It is possible to specify multiple groups by supplying the -g option multiple times.
- It's probably easier not to use the -N option, as the group devices named would have to reference the registered device mapper names.
- Using the -T option will display the group totals only.

iostat

```
[ben@lab ~]$ iostat -V
sysstat version 10.0.5
(C) Sebastien Godard (sysstat <at> orange.fr)

[ben@lab ~]$ iostat -dx -g MyLVM dm-0 dm-1 dm-2 -g Other sda
Linux 3.8.4-102.fc17.x86_64 (lab.mysqlhome)    04/10/2013     _x86_64_       (2 CPU)

Device:         rrqm/s   wrqm/s     r/s     w/s    rkB/s    wkB/s avgrq-sz avgqu-sz   await r_await w_await  svctm  %util
dm-0              0.00     0.00    2.28    0.76    45.53     4.73    33.15     0.24   80.12   32.12  224.36   5.08   1.54
dm-1              0.00     0.00    0.86    5.40    10.57    37.45    15.36     0.25   39.96   32.60   41.13   6.40   4.00
dm-2              0.00     0.00    0.03    0.16     0.09     1.02    11.63     0.01   49.64   26.96   54.00  14.57   0.28
 MyLVM            0.00     0.00    3.16    6.31    56.19    43.20    20.97     0.50   53.01   32.20   63.44   6.15   1.94
sda               0.83     2.59    2.36    4.07    56.42    43.20    30.96     0.37   57.73   26.67   75.73   8.14   5.24
 Other            0.83     2.59    2.36    4.07    56.42    43.20    30.96     0.37   57.73   26.67   75.73   8.14   5.24

[ben@lab ~]$ iostat -dxT -g MyLVM dm-0 dm-1 dm-2 -g Other sda
Linux 3.8.4-102.fc17.x86_64 (lab.mysqlhome)    04/10/2013     _x86_64_       (2 CPU)

Device:         rrqm/s   wrqm/s     r/s     w/s    rkB/s    wkB/s avgrq-sz avgqu-sz   await r_await w_await  svctm  %util
 MyLVM            0.00     0.00    3.16    6.31    56.18    43.20    20.97     0.50   53.01   32.20   63.44   6.14   1.94
 Other            0.83     2.59    2.36    4.08    56.41    43.20    30.96     0.37   57.73   26.67   75.72   8.14   5.24
```

iostat

- The Device Utilization report can be produced on a partition level using the -p option.
- Historically partition statistics were restricted when moving from the 2.4 kernel to 2.6 kernel, however the enhanced statistics were made available again from the 2.6.25 kernel.
- The -p option was mutually exclusive to the -x option up unto version 8.1.8
- The partition focused report, can be limited to specific devices but not specific partitions.
- Currently the group options (-g and -T) don't work well with the partition focused report.

iostat

```
[ben@lab ~]$ iostat -p -dx
Linux 3.8.4-102.fc17.x86_64 (lab.mysqlhome)    04/10/2013     _x86_64_       (2 CPU)

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               5.40     4.94   11.35    9.14   398.26    87.99    47.46     2.33  113.75   56.49  184.87   6.23  12.76
sda1              0.03     0.00    0.23    0.00     0.93     0.00     8.08     0.00   15.88   15.76   60.00  15.87   0.36
sda2              0.02     0.00    0.17    0.00     0.78     0.00     8.93     0.00   10.78   10.78    0.00  10.78   0.19
sda3              5.36     4.94   10.84    8.19   396.12    87.99    50.90     2.29  120.11   58.50  201.69   5.21   9.92
dm-0              0.00     0.00    9.89    2.11   311.61     9.37    53.51     2.86  238.35  119.45  796.49   4.74   5.69
dm-1              0.00     0.00    6.21   11.34    83.31    78.09    18.39     0.90   51.56   24.04   66.64   5.19   9.10
dm-2              0.00     0.00    0.25    0.13     0.94     0.53     7.68     0.01   36.07   27.53   51.99  11.56   0.44


[ben@lab ~]$ iostat -p sda -dx
Linux 3.8.4-102.fc17.x86_64 (lab.mysqlhome)    04/10/2013     _x86_64_       (2 CPU)

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               2.68     4.74    6.52    9.47   235.60    90.11    40.73     1.45   90.48   50.74  117.86   6.92  11.07
sda1              0.01     0.00    0.11    0.00     0.45     0.00     8.08     0.00   15.88   15.76   60.00  15.87   0.18
sda2              0.01     0.00    0.08    0.00     0.37     0.00     8.93     0.00   10.78   10.78    0.00  10.78   0.09
sda3              2.66     4.74    6.28    8.40   234.56    90.11    44.23     1.40   95.45   52.19  127.77   5.22   7.67
```

pt-diskstats

- pt-diskstats is part of the percona toolkit.
- pt-diskstats is open source software written in Perl, and is available under the GNU General Public License, version 2.
- Other utilities in the percona toolkit include pt-stalk, pt-table-checksum, pt-table-sync, pt-query-digest, and pt-summary.
- Percona toolkit can be downloaded from http://www.percona.com/software/percona-toolkit/

  or more simply from the command line:

  ```
  wget percona.com/get/percona-toolkit.tar.gz
  ```
- Tools can also be downloaded individually:

  ```
  wget percona.com/get/TOOL
  ```

  e.g. `wget percona.com/get/pt-diskstats`

pt-diskstats

- At the time of writing the current stable version of percona toolkit is version 2.1.1.
- Full documentation of pt-diskstats can be found here:

  http://www.percona.com/doc/percona-toolkit/2.1/pt-diskstats.html
- The version of pt-diskstats you have installed can be found with --version option.

```
[ben@lab ~]$ ./pt-diskstats --version
pt-diskstats 2.2.1
```

pt-diskstats

- By default pt-diskstats produces useful stats reporting current device activity. Inactive devices are hidden, but subsequently added if they become active.
- The default invocation shows the statistics for the last interval (which by default is 1 second), and will continue until interrupted.
- Similar to: iostat -dx***y*** 1

```
[ben@lab ~]$ ./pt-diskstats
  #ts device    rd_s rd_avkb rd_mb_s rd_mrg rd_cnc   rd_rt    wr_s wr_avkb wr_mb_s wr_mrg wr_cnc   wr_rt busy in_prg    io_s  qtime stime
  1.0 sda       0.0     0.0     0.0     0%    0.0    0.0     1.0     8.0     0.0    50%    0.0    0.0    4%      1     1.0   -5.8  17.5
  1.0 sda3      0.0     0.0     0.0     0%    0.0    0.0     1.0     8.0     0.0    50%    0.0    0.0    0%      0     1.0    0.0   0.0
  1.0 dm-2      0.0     0.0     0.0     0%    0.0    0.0     3.0     4.0     0.0     0%    0.0    0.0    4%      1     3.0   -2.9  11.7

  1.0 sda       1.0     4.0     0.0     0%    0.1   72.0    13.0     4.0     0.1    32%    0.2   11.1   25%      0    14.0    0.7  12.3
  1.0 sda3      1.0     4.0     0.0     0%    0.1   72.0     7.0     7.4     0.1    46%    0.0    1.4    9%      0     8.0    0.0   6.4
  1.0 dm-1      1.0     4.0     0.0     0%    0.1   72.0    16.0     3.0     0.0     0%    0.1    8.8   21%      0    17.0    0.4  12.1
  1.0 dm-2      0.0     0.0     0.0     0%    0.0    0.0     0.0     0.0     0.0     0%    0.1    0.0    4%      0     0.0    0.0   0.0

  1.0 sda       0.0     0.0     0.0     0%    0.0    0.0     1.0    28.0     0.0    86%    0.0    0.0    4%      1     1.0   -0.6   5.0
  1.0 sda3      0.0     0.0     0.0     0%    0.0    0.0     1.0    28.0     0.0    86%    0.0    0.0    0%      0     1.0    0.0   0.0
  1.0 dm-1      0.0     0.0     0.0     0%    0.0    0.0     0.0     0.0     0.0     0%    0.0    0.0    0%      0     0.0    0.0   0.0
  1.0 dm-2      0.0     0.0     0.0     0%    0.0    0.0     0.0     0.0     0.0     0%    0.0    0.0    0%      0     0.0    0.0   0.0
```

pt-diskstats

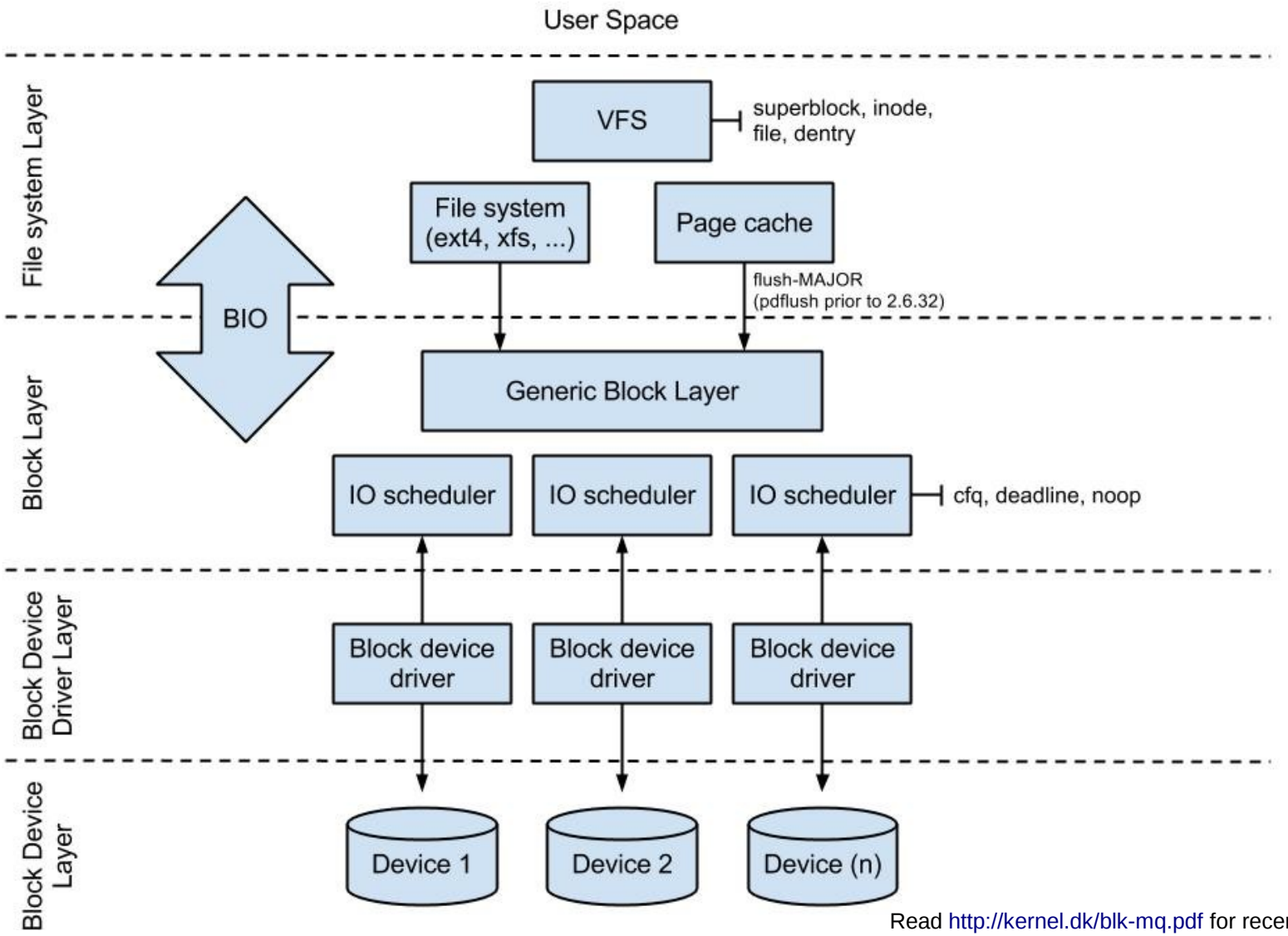
- The interval can be adjusted using the --interval option
- The number of samples can be limited using the --iterations option.
- Similar to: iostat -dx***y*** 3 3

```
[ben@lab ~]$ ./pt-diskstats --interval 3 --iterations 3

  #ts device    rd_s rd_avkb rd_mb_s rd_mrg rd_cnc   rd_rt    wr_s wr_avkb wr_mb_s wr_mrg wr_cnc   wr_rt busy in_prg    io_s  qtime stime
  3.0 sda        0.0     0.0     0.0     0%    0.0     0.0     1.3     3.0     0.0     0%    0.0    37.2   4%      0     1.3    9.4  28.2
  3.0 sda3       0.0     0.0     0.0     0%    0.0     0.0     1.0     4.0     0.0     0%    0.0    22.7   2%      0     1.0    0.0  22.7
  3.0 dm-1       0.0     0.0     0.0     0%    0.0     0.0     0.0     0.0     0.0     0%    0.0     0.0   2%      0     0.0    0.0   0.0
  3.0 dm-2       0.0     0.0     0.0     0%    0.0     0.0     0.7     4.0     0.0     0%    0.0    30.0   2%      0     0.7    0.0  30.0

  3.0 sda        0.0     0.0     0.0     0%    0.0     0.0     1.3     6.0     0.0    50%    0.0    10.1   4%      2     1.3    0.7  14.6
  3.0 sda3       0.0     0.0     0.0     0%    0.0     0.0     1.0     8.0     0.0    57%    0.0     1.1   1%      1     1.0   -0.8   6.3
  3.0 dm-0       0.0     0.0     0.0     0%    0.0     0.0     0.7     4.0     0.0     0%    0.0     0.0   1%      2     0.7    0.0  18.0
  3.0 dm-1       0.0     0.0     0.0     0%    0.0     0.0     1.3     4.0     0.0     0%    0.0     0.0   1%      1     1.3   -1.8   9.0
  3.0 dm-2       0.0     0.0     0.0     0%    0.0     0.0     1.0     4.0     0.0     0%    0.0    27.0   3%      0     1.0    0.0  27.0

  3.0 sda        0.0     0.0     0.0     0%    0.0     0.0     2.3     3.4     0.0     0%    0.1    43.4   5%      0     2.3   26.4  20.0
  3.0 sda3       0.0     0.0     0.0     0%    0.0     0.0     1.7     4.8     0.0     0%    0.1    33.4   3%      0     1.7   12.1  20.6
  3.0 dm-0       0.0     0.0     0.0     0%    0.0     0.0     0.3     4.0     0.0     0%    0.1   191.0   3%      0     0.3 -211.0  92.0
  3.0 dm-1       0.0     0.0     0.0     0%    0.0     0.0     0.0     0.0     0.0     0%    0.0     0.0   3%      0     0.0    0.0   0.0
  3.0 dm-2       0.0     0.0     0.0     0%    0.0     0.0     0.7     4.0     0.0     0%    0.0    23.5   2%      0     0.7    0.0  23.5
```

pt-diskstats

- Displayed columns can be restricted using perl regex with the --columns-regex option.
- Displayed devices can be restricted using perl regex with the --devices-regex option.
- Adding the --show-timestamps option will include a timestamp with each report.
- The output can be grouped by sample or by disk using the --group-by option.
- Samples (of /proc/diskstats) can be saved for later analysis using the --save-samples option.
- Contrary to the documentation --version-check is enabled by default, if you wear a tin foil hat, disable using --noversion-check.

The interlude: A primer in Linux IO



Read http://kernel.dk/blk-mq.pdf for recent development

A primer in Linux IO

- Applications in the user space make requests to the VFS.
- The request is passed to the block layer if the page is not in the page cache or the request is made using direct IO.
- Requests in the block layer can be split if the request is across multiple devices, or remapped from a device partition to the underlying block device.
- Requests are handled by the IO scheduler on a per block device basis. Dependent on the scheduler, the request could be merged to the front or back of existing requests (all schedulers), or sorted in the request queue (cfq & deadline). The anticipatory scheduler was removed from the kernel in version 2.6.33.
- Statistics are calculated at the block layer.

A primer in Linux IO

- To understand what is acceptable performance there's no substitute to understanding the block device hardware.
- A block device is an abstraction, potentially it could be a 10 disk array with a hardware RAID controller, it could be a LUN exposed from a SAN, even if it's a single disk, the expected disk performance could vary greatly dependent on it's specification.
- Expected IOPs, latency and throughput can be gathered via benchmarks or estimated using calculations:
  - http://www.techish.net/hardware/iops-calculator-and-raid-calculators-estimators/
  - http://www.wmarow.com/strcalc/
- As a rough estimate you can expect:

  75-100 iops from a 7200 rpm disk

  125-150 iops from 10k rpm disk

  175-200 iops from 15k rpm disk

  1000's iops from SSD (++++++++++)

Block layer disk statistics

- From the 2.6 kernel, statistics are held for all block devices and partitions in /proc/diskstats.
- /proc/diskstats lists the block devices major number, minor number, and name as well as a statistic set of 11 counters.
- Prior to 2.6.25 the statistic set of partitions was only made up of 4 counters and the counters weren't consistent with the underlying block device statistics.
- Statistics are also held for individual devices and partitions in sysfs.
- /sys/block/[dev]/stat holds the statistic set for the device.
- /sys/block/[dev]/[partition]/stat holds the statistic set for the device partition.

/proc/diskstats (2.6.25+)

```
[ben@lab ~]$ cat /proc/diskstats
   7       0 loop0 0 0 0 0 0 0 0 0 0 0 0
   7       1 loop1 0 0 0 0 0 0 0 0 0 0 0
   7       2 loop2 0 0 0 0 0 0 0 0 0 0 0
   7       3 loop3 0 0 0 0 0 0 0 0 0 0 0
   7       4 loop4 0 0 0 0 0 0 0 0 0 0 0
   7       5 loop5 0 0 0 0 0 0 0 0 0 0 0
   7       6 loop6 0 0 0 0 0 0 0 0 0 0 0
   7       7 loop7 0 0 0 0 0 0 0 0 0 0 0
   8       0 sda 44783 15470 2257302 1210711 85999 54224 1808924 6087675 0 1087763 7298349
   8       1 sda1 463 163 4176 6464 2 0 4 1 0 6215 6465
   8       2 sda2 267 31 2136 4146 0 0 0 0 0 4053 4146
   8       3 sda3 43885 15276 2249646 1197369 73520 54224 1808920 5575620 0 654552 6772954
  11       0 sr0 0 0 0 0 0 0 0 0 0 0 0
 253       0 dm-0 42736 0 1796226 1391325 15414 0 187656 3199366 0 304001 4590697
 253       1 dm-1 16476 0 449218 530482 113707 0 1572032 4549033 0 838217 5079524
 253       2 dm-2 574 0 3410 15473 3747 0 49232 185560 0 61399 201034
```

/sys/block/[dev]/stat

```
[ben@lab ~]$ cat /sys/block/sda/stat
   45000    15470  2262294  1214926    90353    56750  1906276  6249938        0  1133119  7464821

[ben@lab ~]$ cat /sys/block/sda/sda1/stat
     463      163     4176     6464        2        0        4        1        0     6215     6465
[ben@lab ~]$ cat /sys/block/sda/sda2/stat
     267       31     2136     4146        0        0        0        0        0     4053     4146
[ben@lab ~]$ cat /sys/block/sda/sda3/stat
   44102    15276  2254638  1201584    77382    56796  1907296  5715314        0   679274  6916857
```

Block layer disk statistics

Field 1 – **read_IOs**: Total number of reads completed (***requests***)

Field 2 – **read_merges**: Total number of reads merged (***requests***)

Field 3 – **read_sectors**: Total number of sectors read (***sectors***)

Field 4 – **read_ticks**: Total time spent reading (***milliseconds***)

Field 5 – **write_IOs**: Total number of writes completed (***requests***)

Field 6 – **write_merges**: Total number of writes merged (***requests***)

Field 7 – **write_sectors**: Total number of sectors written (***sectors***)

Field 8 – **write_ticks**: Total time spent writing (***milliseconds***)

Field 9 – **in_flight**: The number of I/Os *currently* in flight. It does not include I/O requests that are in the queue but not yet issued to the device driver. (***requests***)

Field 10 – **io_ticks**: This value counts the time during which the device has had I/O requests queued. (***milliseconds***)

Field 11 – **time_in_queue**: The number of I/Os in progress (field 9) times the number of milliseconds spent doing I/O since the last update of this field. (***milliseconds***)

iostat – extended statistics

```
[ben@lab ~]$ iostat -dx 3 3
Linux 3.8.4-102.fc17.x86_64 (lab.mysqlhome)    04/10/2013     _x86_64_       (2 CPU)

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               1.16     2.66    2.89    4.27    70.37    44.66    32.10     0.46   64.37   29.55   87.96   7.94   5.69
dm-0              0.00     0.00    2.80    0.78    55.53     5.23    33.94     0.32   90.12   35.83  286.38   5.03   1.80
dm-1              0.00     0.00    1.17    5.68    14.39    38.73    15.50     0.29   42.12   32.81   44.05   6.38   4.37
dm-2              0.00     0.00    0.04    0.11     0.13     0.70    10.68     0.01   63.30   26.96   77.34  15.47   0.24

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               0.00     4.67    0.00    1.00     0.00    21.33    42.67     0.02   23.33    0.00   23.33  23.33   2.33
dm-0              0.00     0.00    0.00    0.00     0.00     0.00     0.00     0.00    0.00    0.00    0.00   0.00   0.00
dm-1              0.00     0.00    0.00    5.33     0.00    21.33     8.00     0.03    5.25    0.00    5.25   4.38   2.33
dm-2              0.00     0.00    0.00    0.00     0.00     0.00     0.00     0.00    0.00    0.00    0.00   0.00   0.00

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               0.00     1.67    0.00    9.00     0.00    41.33     9.19     0.45   50.44    0.00   50.44   6.52   5.87
dm-0              0.00     0.00    0.00    0.00     0.00     0.00     0.00     0.00    0.00    0.00    0.00   0.00   0.00
dm-1              0.00     0.00    0.00    8.33     0.00    33.33     8.00     0.46   54.92    0.00   54.92   2.52   2.10
dm-2              0.00     0.00    0.00    2.00     0.00     8.00     8.00     0.09   45.50    0.00   45.50  18.83   3.77
```

iostat – extended statistics

```
[ben@lab ~]$ iostat -dx 3 3
Linux 3.8.4-102.fc17.x86_64 (lab.mysqlhome)    04/10/2013     _x86_64_       (2 CPU)
```

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	1.16	2.66	2.89	4.27	70.37	44.66	32.10	0.46	64.37	29.55	87.96	7.94	5.69
dm-0	0.00	0.00	2.80	0.78	55.53	5.23	33.94	0.32	90.12	35.83	286.38	5.03	1.80
dm-1	0.00	0.00	1.17	5.68	14.39	38.73	15.50	0.29	42.12	32.81	44.05	6.38	4.37
dm-2	0.00	0.00	0.04	0.11	0.13	0.70	10.68	0.01	63.30	26.96	77.34	15.47	0.24

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	0.00	4.67	0.00	1.00	0.00	21.33	42.67	0.02	23.33	0.00	23.33	23.33	2.33
dm-0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
dm-1	0.00	0.00	0.00	5.33	0.00	21.33	8.00	0.03	5.25	0.00	5.25	4.38	2.33
dm-2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

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	0.00	1.67	0.00	9.00	0.00	41.33	9.19	0.45	50.44	0.00	50.44	6.52	5.87
dm-0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
dm-1	0.00	0.00	0.00	8.33	0.00	33.33	8.00	0.46	54.92	0.00	54.92	2.52	2.10
dm-2	0.00	0.00	0.00	2.00	0.00	8.00	8.00	0.09	45.50	0.00	45.50	18.83	3.77

iostat - extended statistics

- **rrqm/s (*requests*)**

  delta[read_merges(f2)] / interval

- **wrqm/s (*requests*)**

  delta[write_merges(f6)] / interval

- **r/s (*requests*)**

  delta[read_IOs(f1)] / interval

- **w/s (*requests*)**

  delta[write_IOs(f5)] / interval

iostat – extended statistics

```
[ben@lab ~]$ iostat -dx 3 3
Linux 3.8.4-102.fc17.x86_64 (lab.mysqlhome)    04/10/2013     _x86_64_       (2 CPU)
```

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	1.16	2.66	2.89	4.27	**70.37**	**44.66**	**32.10**	0.46	64.37	29.55	87.96	7.94	5.69
dm-0	0.00	0.00	2.80	0.78	**55.53**	**5.23**	**33.94**	0.32	90.12	35.83	286.38	5.03	1.80
dm-1	0.00	0.00	1.17	5.68	**14.39**	**38.73**	**15.50**	0.29	42.12	32.81	44.05	6.38	4.37
dm-2	0.00	0.00	0.04	0.11	**0.13**	**0.70**	**10.68**	0.01	63.30	26.96	77.34	15.47	0.24

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	0.00	4.67	0.00	1.00	**0.00**	**21.33**	**42.67**	0.02	23.33	0.00	23.33	23.33	2.33
dm-0	0.00	0.00	0.00	0.00	**0.00**	**0.00**	**0.00**	0.00	0.00	0.00	0.00	0.00	0.00
dm-1	0.00	0.00	0.00	5.33	**0.00**	**21.33**	**8.00**	0.03	5.25	0.00	5.25	4.38	2.33
dm-2	0.00	0.00	0.00	0.00	**0.00**	**0.00**	**0.00**	0.00	0.00	0.00	0.00	0.00	0.00

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	0.00	1.67	0.00	9.00	**0.00**	**41.33**	**9.19**	0.45	50.44	0.00	50.44	6.52	5.87
dm-0	0.00	0.00	0.00	0.00	**0.00**	**0.00**	**0.00**	0.00	0.00	0.00	0.00	0.00	0.00
dm-1	0.00	0.00	0.00	8.33	**0.00**	**33.33**	**8.00**	0.46	54.92	0.00	54.92	2.52	2.10
dm-2	0.00	0.00	0.00	2.00	**0.00**	**8.00**	**8.00**	0.09	45.50	0.00	45.50	18.83	3.77

iostat - extended statistics

- **rkB/s (*sectors*|*kB*|*mB*)**

  (delta[read_sectors(f3)] / interval) / conversion factor

- **wkB/s (*sectors*|*kB*|*mB*)**

  (delta[write_sectors(f7)] / interval) / conversion factor

- **avgrq-sz (*sectors*)**

  delta[read_sectors(f3) + write_sectors(f7)] /
  delta[read_IOs(f1) + write_IOs(f5)]

  (or 0.0 if no IO)

iostat - extended statistics

```
[ben@lab ~]$ iostat -dx 3 3
Linux 3.8.4-102.fc17.x86_64 (lab.mysqlhome)    04/10/2013     _x86_64_       (2 CPU)
```

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	1.16	2.66	2.89	4.27	70.37	44.66	32.10	**0.46**	**64.37**	29.55	87.96	7.94	5.69
dm-0	0.00	0.00	2.80	0.78	55.53	5.23	33.94	**0.32**	**90.12**	35.83	286.38	5.03	1.80
dm-1	0.00	0.00	1.17	5.68	14.39	38.73	15.50	**0.29**	**42.12**	32.81	44.05	6.38	4.37
dm-2	0.00	0.00	0.04	0.11	0.13	0.70	10.68	**0.01**	**63.30**	26.96	77.34	15.47	0.24

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	0.00	4.67	0.00	1.00	0.00	21.33	42.67	**0.02**	**23.33**	0.00	23.33	23.33	2.33
dm-0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**	**0.00**	0.00	0.00	0.00	0.00
dm-1	0.00	0.00	0.00	5.33	0.00	21.33	8.00	**0.03**	**5.25**	0.00	5.25	4.38	2.33
dm-2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**	**0.00**	0.00	0.00	0.00	0.00

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	0.00	1.67	0.00	9.00	0.00	41.33	9.19	**0.45**	**50.44**	0.00	50.44	6.52	5.87
dm-0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**	**0.00**	0.00	0.00	0.00	0.00
dm-1	0.00	0.00	0.00	8.33	0.00	33.33	8.00	**0.46**	**54.92**	0.00	54.92	2.52	2.10
dm-2	0.00	0.00	0.00	2.00	0.00	8.00	8.00	**0.09**	**45.50**	0.00	45.50	18.83	3.77

iostat - extended statistics

- **avgqu-sz (*requests*)**

  (delta[time_in_queue(f11)] / interval) / 1000.0

- **await (*milliseconds*)**

  delta[read_ticks(f4) + write_ticks(f8)] /

  delta[read_IOs(f1) + write_IOs(f5)]

  (or 0.0 if no IO)

iostat – extended statistics

```
[ben@lab ~]$ iostat -dx 3 3
Linux 3.8.4-102.fc17.x86_64 (lab.mysqlhome)    04/10/2013     _x86_64_       (2 CPU)
```

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	1.16	2.66	2.89	4.27	70.37	44.66	32.10	0.46	64.37	**29.55**	**87.96**	7.94	5.69
dm-0	0.00	0.00	2.80	0.78	55.53	5.23	33.94	0.32	90.12	**35.83**	**286.38**	5.03	1.80
dm-1	0.00	0.00	1.17	5.68	14.39	38.73	15.50	0.29	42.12	**32.81**	**44.05**	6.38	4.37
dm-2	0.00	0.00	0.04	0.11	0.13	0.70	10.68	0.01	63.30	**26.96**	**77.34**	15.47	0.24

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	0.00	4.67	0.00	1.00	0.00	21.33	42.67	0.02	23.33	**0.00**	**23.33**	23.33	2.33
dm-0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**	**0.00**	0.00	0.00
dm-1	0.00	0.00	0.00	5.33	0.00	21.33	8.00	0.03	5.25	**0.00**	**5.25**	4.38	2.33
dm-2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**	**0.00**	0.00	0.00

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	0.00	1.67	0.00	9.00	0.00	41.33	9.19	0.45	50.44	**0.00**	**50.44**	6.52	5.87
dm-0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**	**0.00**	0.00	0.00
dm-1	0.00	0.00	0.00	8.33	0.00	33.33	8.00	0.46	54.92	**0.00**	**54.92**	2.52	2.10
dm-2	0.00	0.00	0.00	2.00	0.00	8.00	8.00	0.09	45.50	**0.00**	**45.50**	18.83	3.77

iostat - extended statistics

- **r_await (*milliseconds*)**

  delta[read_ticks(f4)] / delta[read_IOs(f1)]

  (or 0.0 if no read IOs)

- **w_await (*milliseconds*)**

  delta[write_ticks(f8)] / delta[write_IOs(f5)]

  (or 0.0 if no write IOs)

iostat – extended statistics

```
[ben@lab ~]$ iostat -dx 3 3
Linux 3.8.4-102.fc17.x86_64 (lab.mysqlhome)    04/10/2013     _x86_64_       (2 CPU)
```

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	1.16	2.66	2.89	4.27	70.37	44.66	32.10	0.46	64.37	29.55	87.96	**7.94**	**5.69**
dm-0	0.00	0.00	2.80	0.78	55.53	5.23	33.94	0.32	90.12	35.83	286.38	**5.03**	**1.80**
dm-1	0.00	0.00	1.17	5.68	14.39	38.73	15.50	0.29	42.12	32.81	44.05	**6.38**	**4.37**
dm-2	0.00	0.00	0.04	0.11	0.13	0.70	10.68	0.01	63.30	26.96	77.34	**15.47**	**0.24**

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	0.00	4.67	0.00	1.00	0.00	21.33	42.67	0.02	23.33	0.00	23.33	**23.33**	**2.33**
dm-0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**	**0.00**
dm-1	0.00	0.00	0.00	5.33	0.00	21.33	8.00	0.03	5.25	0.00	5.25	**4.38**	**2.33**
dm-2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**	**0.00**

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	0.00	1.67	0.00	9.00	0.00	41.33	9.19	0.45	50.44	0.00	50.44	**6.52**	**5.87**
dm-0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**	**0.00**
dm-1	0.00	0.00	0.00	8.33	0.00	33.33	8.00	0.46	54.92	0.00	54.92	**2.52**	**2.10**
dm-2	0.00	0.00	0.00	2.00	0.00	8.00	8.00	0.09	45.50	0.00	45.50	**18.83**	**3.77**

iostat - extended statistics

- **svctm (*milliseconds*)**

  ((delta[read_IOs(f1) + write_IOs(f5)] * HZ) / interval) / (delta[IO_ticks(f10)] / interval)

  (or 0.0 if tput = 0)

  * HZ = ticks per second, (1000 on most systems).

  ** This field will be removed in a future sysstat version.

- **%util (*percent*)**

  ((delta[IO_ticks(f10)] / interval) / 10) / devices

  * devices = 1 or the number of devices in the group (-g option).

pt-diskstats

```
[ben@lab ~]$ ./pt-diskstats --interval 3 --iterations 3
```

#ts	device	rd_s	rd_avkb	rd_mb_s	rd_mrg	rd_cnc	rd_rt	wr_s	wr_avkb	wr_mb_s	wr_mrg	wr_cnc	wr_rt	busy	in_prg	io_s	qtime	stime
3.0	sda	0.0	0.0	0.0	0%	0.0	0.0	1.3	3.0	0.0	0%	0.0	37.2	4%	0	1.3	9.4	28.2
3.0	sda3	0.0	0.0	0.0	0%	0.0	0.0	1.0	4.0	0.0	0%	0.0	22.7	2%	0	1.0	0.0	22.7
3.0	dm-1	0.0	0.0	0.0	0%	0.0	0.0	0.0	0.0	0.0	0%	0.0	0.0	2%	0	0.0	0.0	0.0
3.0	dm-2	0.0	0.0	0.0	0%	0.0	0.0	0.7	4.0	0.0	0%	0.0	30.0	2%	0	0.7	0.0	30.0
3.0	sda	0.0	0.0	0.0	0%	0.0	0.0	1.3	6.0	0.0	50%	0.0	10.1	4%	2	1.3	0.7	14.6
3.0	sda3	0.0	0.0	0.0	0%	0.0	0.0	1.0	8.0	0.0	57%	0.0	1.1	1%	1	1.0	-0.8	6.3
3.0	dm-0	0.0	0.0	0.0	0%	0.0	0.0	0.7	4.0	0.0	0%	0.0	0.0	1%	2	0.7	0.0	18.0
3.0	dm-1	0.0	0.0	0.0	0%	0.0	0.0	1.3	4.0	0.0	0%	0.0	0.0	1%	1	1.3	-1.8	9.0
3.0	dm-2	0.0	0.0	0.0	0%	0.0	0.0	1.0	4.0	0.0	0%	0.0	27.0	3%	0	1.0	0.0	27.0
3.0	sda	0.0	0.0	0.0	0%	0.0	0.0	2.3	3.4	0.0	0%	0.1	43.4	5%	0	2.3	26.4	20.0
3.0	sda3	0.0	0.0	0.0	0%	0.0	0.0	1.7	4.8	0.0	0%	0.1	33.4	3%	0	1.7	12.1	20.6
3.0	dm-0	0.0	0.0	0.0	0%	0.0	0.0	0.3	4.0	0.0	0%	0.1	191.0	3%	0	0.3	-211.0	92.0
3.0	dm-1	0.0	0.0	0.0	0%	0.0	0.0	0.0	0.0	0.0	0%	0.0	0.0	3%	0	0.0	0.0	0.0
3.0	dm-2	0.0	0.0	0.0	0%	0.0	0.0	0.7	4.0	0.0	0%	0.0	23.5	2%	0	0.7	0.0	23.5

pt-diskstats

```
[ben@lab ~]$ ./pt-diskstats --interval 3 --iterations 3
```

#ts	device	rd_s	rd_avkb	rd_mb_s	rd_mrg	rd_cnc	rd_rt	wr_s	wr_avkb	wr_mb_s	wr_mrg	wr_cnc	wr_rt	busy	in_prg	io_s	qtime	stime
3.0	sda	**0.0**	**0.0**	**0.0**	**0%**	0.0	0.0	1.3	3.0	0.0	0%	0.0	37.2	4%	0	1.3	9.4	28.2
3.0	sda3	**0.0**	**0.0**	**0.0**	**0%**	0.0	0.0	1.0	4.0	0.0	0%	0.0	22.7	2%	0	1.0	0.0	22.7
3.0	dm-1	**0.0**	**0.0**	**0.0**	**0%**	0.0	0.0	0.0	0.0	0.0	0%	0.0	0.0	2%	0	0.0	0.0	0.0
3.0	dm-2	**0.0**	**0.0**	**0.0**	**0%**	0.0	0.0	0.7	4.0	0.0	0%	0.0	30.0	2%	0	0.7	0.0	30.0
3.0	sda	**0.0**	**0.0**	**0.0**	**0%**	0.0	0.0	1.3	6.0	0.0	50%	0.0	10.1	4%	2	1.3	0.7	14.6
3.0	sda3	**0.0**	**0.0**	**0.0**	**0%**	0.0	0.0	1.0	8.0	0.0	57%	0.0	1.1	1%	1	1.0	-0.8	6.3
3.0	dm-0	**0.0**	**0.0**	**0.0**	**0%**	0.0	0.0	0.7	4.0	0.0	0%	0.0	0.0	1%	2	0.7	0.0	18.0
3.0	dm-1	**0.0**	**0.0**	**0.0**	**0%**	0.0	0.0	1.3	4.0	0.0	0%	0.0	0.0	1%	1	1.3	-1.8	9.0
3.0	dm-2	**0.0**	**0.0**	**0.0**	**0%**	0.0	0.0	1.0	4.0	0.0	0%	0.0	27.0	3%	0	1.0	0.0	27.0
3.0	sda	**0.0**	**0.0**	**0.0**	**0%**	0.0	0.0	2.3	3.4	0.0	0%	0.1	43.4	5%	0	2.3	26.4	20.0
3.0	sda3	**0.0**	**0.0**	**0.0**	**0%**	0.0	0.0	1.7	4.8	0.0	0%	0.1	33.4	3%	0	1.7	12.1	20.6
3.0	dm-0	**0.0**	**0.0**	**0.0**	**0%**	0.0	0.0	0.3	4.0	0.0	0%	0.1	191.0	3%	0	0.3	-211.0	92.0
3.0	dm-1	**0.0**	**0.0**	**0.0**	**0%**	0.0	0.0	0.0	0.0	0.0	0%	0.0	0.0	3%	0	0.0	0.0	0.0
3.0	dm-2	**0.0**	**0.0**	**0.0**	**0%**	0.0	0.0	0.7	4.0	0.0	0%	0.0	23.5	2%	0	0.7	0.0	23.5

pt-diskstats

- **rd_s (*requests*) – Comparable to iostat r/s**

  delta[read_IOs(f1)] / interval

- **rd_avkb (*kB*) – Similar to iostat avgrq-sz but isolates reads**

  conversion factor * delta[read_sectors(f3)] / delta[read_IOs(f1)]

  (Conversion factor = 2 = documentation bug)

- **rd_mb_s (*mB*) – Comparable to iostat rmB/s**

  conversion factor * delta[read_sectors(f3)] / interval

  (Conversion factor = 2 = documentation bug)

- **rd_mrg (*percent*) – Similar to iostat rrqm/s expressed as %**

  100 * delta[read_merges(f2)] / (delta[read_merges(f2)] + delta[read_IOs(f1)])

pt-diskstats

```
[ben@lab ~]$ ./pt-diskstats --interval 3 --iterations 3
```

#ts	device	rd_s	rd_avkb	rd_mb_s	rd_mrg	**rd_cnc**	**rd_rt**	wr_s	wr_avkb	wr_mb_s	wr_mrg	wr_cnc	wr_rt	busy	in_prg	io_s	qtime	stime
3.0	sda	0.0	0.0	0.0	0%	**0.0**	**0.0**	1.3	3.0	0.0	0%	0.0	37.2	4%	0	1.3	9.4	28.2
3.0	sda3	0.0	0.0	0.0	0%	**0.0**	**0.0**	1.0	4.0	0.0	0%	0.0	22.7	2%	0	1.0	0.0	22.7
3.0	dm-1	0.0	0.0	0.0	0%	**0.0**	**0.0**	0.0	0.0	0.0	0%	0.0	0.0	2%	0	0.0	0.0	0.0
3.0	dm-2	0.0	0.0	0.0	0%	**0.0**	**0.0**	0.7	4.0	0.0	0%	0.0	30.0	2%	0	0.7	0.0	30.0
3.0	sda	0.0	0.0	0.0	0%	**0.0**	**0.0**	1.3	6.0	0.0	50%	0.0	10.1	4%	2	1.3	0.7	14.6
3.0	sda3	0.0	0.0	0.0	0%	**0.0**	**0.0**	1.0	8.0	0.0	57%	0.0	1.1	1%	1	1.0	-0.8	6.3
3.0	dm-0	0.0	0.0	0.0	0%	**0.0**	**0.0**	0.7	4.0	0.0	0%	0.0	0.0	1%	2	0.7	0.0	18.0
3.0	dm-1	0.0	0.0	0.0	0%	**0.0**	**0.0**	1.3	4.0	0.0	0%	0.0	0.0	1%	1	1.3	-1.8	9.0
3.0	dm-2	0.0	0.0	0.0	0%	**0.0**	**0.0**	1.0	4.0	0.0	0%	0.0	27.0	3%	0	1.0	0.0	27.0
3.0	sda	0.0	0.0	0.0	0%	**0.0**	**0.0**	2.3	3.4	0.0	0%	0.1	43.4	5%	0	2.3	26.4	20.0
3.0	sda3	0.0	0.0	0.0	0%	**0.0**	**0.0**	1.7	4.8	0.0	0%	0.1	33.4	3%	0	1.7	12.1	20.6
3.0	dm-0	0.0	0.0	0.0	0%	**0.0**	**0.0**	0.3	4.0	0.0	0%	0.1	191.0	3%	0	0.3	-211.0	92.0
3.0	dm-1	0.0	0.0	0.0	0%	**0.0**	**0.0**	0.0	0.0	0.0	0%	0.0	0.0	3%	0	0.0	0.0	0.0
3.0	dm-2	0.0	0.0	0.0	0%	**0.0**	**0.0**	0.7	4.0	0.0	0%	0.0	23.5	2%	0	0.7	0.0	23.5

pt-diskstats

- **rd_cnc – (Little's law) iostat has no equivalent**

  delta[read_ticks(f4)] / interval / 1000 / devices in group

- **rd_rt (milliseconds) – Differs to iostat r_await**

  delta[read_ticks(f4)] /
  (delta[read_IOs(f1)] + delta[read_merges(f2)])

pt-diskstats

```
[ben@lab ~]$ ./pt-diskstats --interval 3 --iterations 3
```

#ts	device	rd_s	rd_avkb	rd_mb_s	rd_mrg	rd_cnc	rd_rt	**wr_s**	**wr_avkb**	**wr_mb_s**	**wr_mrg**	wr_cnc	wr_rt	busy	in_prg	io_s	qtime	stime
3.0	sda	0.0	0.0	0.0	0%	0.0	0.0	**1.3**	**3.0**	**0.0**	**0%**	0.0	37.2	4%	0	1.3	9.4	28.2
3.0	sda3	0.0	0.0	0.0	0%	0.0	0.0	**1.0**	**4.0**	**0.0**	**0%**	0.0	22.7	2%	0	1.0	0.0	22.7
3.0	dm-1	0.0	0.0	0.0	0%	0.0	0.0	**0.0**	**0.0**	**0.0**	**0%**	0.0	0.0	2%	0	0.0	0.0	0.0
3.0	dm-2	0.0	0.0	0.0	0%	0.0	0.0	**0.7**	**4.0**	**0.0**	**0%**	0.0	30.0	2%	0	0.7	0.0	30.0
3.0	sda	0.0	0.0	0.0	0%	0.0	0.0	**1.3**	**6.0**	**0.0**	**50%**	0.0	10.1	4%	2	1.3	0.7	14.6
3.0	sda3	0.0	0.0	0.0	0%	0.0	0.0	**1.0**	**8.0**	**0.0**	**57%**	0.0	1.1	1%	1	1.0	-0.8	6.3
3.0	dm-0	0.0	0.0	0.0	0%	0.0	0.0	**0.7**	**4.0**	**0.0**	**0%**	0.0	0.0	1%	2	0.7	0.0	18.0
3.0	dm-1	0.0	0.0	0.0	0%	0.0	0.0	**1.3**	**4.0**	**0.0**	**0%**	0.0	0.0	1%	1	1.3	-1.8	9.0
3.0	dm-2	0.0	0.0	0.0	0%	0.0	0.0	**1.0**	**4.0**	**0.0**	**0%**	0.0	27.0	3%	0	1.0	0.0	27.0
3.0	sda	0.0	0.0	0.0	0%	0.0	0.0	**2.3**	**3.4**	**0.0**	**0%**	0.1	43.4	5%	0	2.3	26.4	20.0
3.0	sda3	0.0	0.0	0.0	0%	0.0	0.0	**1.7**	**4.8**	**0.0**	**0%**	0.1	33.4	3%	0	1.7	12.1	20.6
3.0	dm-0	0.0	0.0	0.0	0%	0.0	0.0	**0.3**	**4.0**	**0.0**	**0%**	0.1	191.0	3%	0	0.3	-211.0	92.0
3.0	dm-1	0.0	0.0	0.0	0%	0.0	0.0	**0.0**	**0.0**	**0.0**	**0%**	0.0	0.0	3%	0	0.0	0.0	0.0
3.0	dm-2	0.0	0.0	0.0	0%	0.0	0.0	**0.7**	**4.0**	**0.0**	**0%**	0.0	23.5	2%	0	0.7	0.0	23.5

pt-diskstats

- **wr_s (*requests*) — Comparable to iostat w/s**

  delta[write_IOs(f5)] / interval

- **wr_avkb (*kB*) — Similar to iostat avgrq-sz but isolates writes**

  conversion factor * delta[write_sectors(f7)] / delta[write_IOs(f5)]

  (Conversion factor = 2 = documentation bug)

- **wr_mb_s (*mB*) — Comparable to iostat wmB/s**

  conversion factor * delta[write_sectors(f7)] / interval

  (Conversion factor = 2 = documentation bug)

- **wr_mrg (*percent*) — Similar to iostat wrqm/s expressed as %**

  100 * delta[write_merges(f6)] / (delta[write_merges(f6)] + delta[write_IOs(f5)])

pt-diskstats

```
[ben@lab ~]$ ./pt-diskstats --interval 3 --iterations 3
```

#ts	device	rd_s	rd_avkb	rd_mb_s	rd_mrg	rd_cnc	rd_rt	wr_s	wr_avkb	wr_mb_s	wr_mrg	**wr_cnc**	**wr_rt**	busy	in_prg	io_s	qtime	stime
3.0	sda	0.0	0.0	0.0	0%	0.0	0.0	1.3	3.0	0.0	0%	**0.0**	**37.2**	4%	0	1.3	9.4	28.2
3.0	sda3	0.0	0.0	0.0	0%	0.0	0.0	1.0	4.0	0.0	0%	**0.0**	**22.7**	2%	0	1.0	0.0	22.7
3.0	dm-1	0.0	0.0	0.0	0%	0.0	0.0	0.0	0.0	0.0	0%	**0.0**	**0.0**	2%	0	0.0	0.0	0.0
3.0	dm-2	0.0	0.0	0.0	0%	0.0	0.0	0.7	4.0	0.0	0%	**0.0**	**30.0**	2%	0	0.7	0.0	30.0
3.0	sda	0.0	0.0	0.0	0%	0.0	0.0	1.3	6.0	0.0	50%	**0.0**	**10.1**	4%	2	1.3	0.7	14.6
3.0	sda3	0.0	0.0	0.0	0%	0.0	0.0	1.0	8.0	0.0	57%	**0.0**	**1.1**	1%	1	1.0	-0.8	6.3
3.0	dm-0	0.0	0.0	0.0	0%	0.0	0.0	0.7	4.0	0.0	0%	**0.0**	**0.0**	1%	2	0.7	0.0	18.0
3.0	dm-1	0.0	0.0	0.0	0%	0.0	0.0	1.3	4.0	0.0	0%	**0.0**	**0.0**	1%	1	1.3	-1.8	9.0
3.0	dm-2	0.0	0.0	0.0	0%	0.0	0.0	1.0	4.0	0.0	0%	**0.0**	**27.0**	3%	0	1.0	0.0	27.0
3.0	sda	0.0	0.0	0.0	0%	0.0	0.0	2.3	3.4	0.0	0%	**0.1**	**43.4**	5%	0	2.3	26.4	20.0
3.0	sda3	0.0	0.0	0.0	0%	0.0	0.0	1.7	4.8	0.0	0%	**0.1**	**33.4**	3%	0	1.7	12.1	20.6
3.0	dm-0	0.0	0.0	0.0	0%	0.0	0.0	0.3	4.0	0.0	0%	**0.1**	**191.0**	3%	0	0.3	-211.0	92.0
3.0	dm-1	0.0	0.0	0.0	0%	0.0	0.0	0.0	0.0	0.0	0%	**0.0**	**0.0**	3%	0	0.0	0.0	0.0
3.0	dm-2	0.0	0.0	0.0	0%	0.0	0.0	0.7	4.0	0.0	0%	**0.0**	**23.5**	2%	0	0.7	0.0	23.5

pt-diskstats

- **wr_cnc – (Little's law) iostat has no equivalent**

  delta[write_ticks(f8)] / interval / 1000 / devices in group

- **wr_rt (milliseconds) – Differs to iostat w_await**

  delta[write_ticks(f8)] /
  (delta[write_IOs(f5)] + delta[write_merges(f6)])

pt-diskstats

```
[ben@lab ~]$ ./pt-diskstats --interval 3 --iterations 3
```

#ts	device	rd_s	rd_avkb	rd_mb_s	rd_mrg	rd_cnc	rd_rt	wr_s	wr_avkb	wr_mb_s	wr_mrg	wr_cnc	wr_rt	**busy**	**in_prg**	**io_s**	qtime	stime
3.0	sda	0.0	0.0	0.0	0%	0.0	0.0	1.3	3.0	0.0	0%	0.0	37.2	**4%**	**0**	**1.3**	9.4	28.2
3.0	sda3	0.0	0.0	0.0	0%	0.0	0.0	1.0	4.0	0.0	0%	0.0	22.7	**2%**	**0**	**1.0**	0.0	22.7
3.0	dm-1	0.0	0.0	0.0	0%	0.0	0.0	0.0	0.0	0.0	0%	0.0	0.0	**2%**	**0**	**0.0**	0.0	0.0
3.0	dm-2	0.0	0.0	0.0	0%	0.0	0.0	0.7	4.0	0.0	0%	0.0	30.0	**2%**	**0**	**0.7**	0.0	30.0
3.0	sda	0.0	0.0	0.0	0%	0.0	0.0	1.3	6.0	0.0	50%	0.0	10.1	**4%**	**2**	**1.3**	0.7	14.6
3.0	sda3	0.0	0.0	0.0	0%	0.0	0.0	1.0	8.0	0.0	57%	0.0	1.1	**1%**	**1**	**1.0**	-0.8	6.3
3.0	dm-0	0.0	0.0	0.0	0%	0.0	0.0	0.7	4.0	0.0	0%	0.0	0.0	**1%**	**2**	**0.7**	0.0	18.0
3.0	dm-1	0.0	0.0	0.0	0%	0.0	0.0	1.3	4.0	0.0	0%	0.0	0.0	**1%**	**1**	**1.3**	-1.8	9.0
3.0	dm-2	0.0	0.0	0.0	0%	0.0	0.0	1.0	4.0	0.0	0%	0.0	27.0	**3%**	**0**	**1.0**	0.0	27.0
3.0	sda	0.0	0.0	0.0	0%	0.0	0.0	2.3	3.4	0.0	0%	0.1	43.4	**5%**	**0**	**2.3**	26.4	20.0
3.0	sda3	0.0	0.0	0.0	0%	0.0	0.0	1.7	4.8	0.0	0%	0.1	33.4	**3%**	**0**	**1.7**	12.1	20.6
3.0	dm-0	0.0	0.0	0.0	0%	0.0	0.0	0.3	4.0	0.0	0%	0.1	191.0	**3%**	**0**	**0.3**	-211.0	92.0
3.0	dm-1	0.0	0.0	0.0	0%	0.0	0.0	0.0	0.0	0.0	0%	0.0	0.0	**3%**	**0**	**0.0**	0.0	0.0
3.0	dm-2	0.0	0.0	0.0	0%	0.0	0.0	0.7	4.0	0.0	0%	0.0	23.5	**2%**	**0**	**0.7**	0.0	23.5

pt-diskstats

- **busy (percent) – Comparable to iostat %util**

  100 * delta[io_ticks(f10)] / (1000 * interval)

- **in_prg (requests) – iostat has no equivalent - # BIOs**

  in_flight(f9)

- **ios_s (requests) – Comparable to iostat r/s + w/s**

  (delta[read IOs(f1)] + delta[write_IOs(f5)]) / interval

pt-diskstats

```
[ben@lab ~]$ ./pt-diskstats --interval 3 --iterations 3
```

#ts	device	rd_s	rd_avkb	rd_mb_s	rd_mrg	rd_cnc	rd_rt	wr_s	wr_avkb	wr_mb_s	wr_mrg	wr_cnc	wr_rt	busy	in_prg	io_s	qtime	stime
3.0	sda	0.0	0.0	0.0	0%	0.0	0.0	1.3	3.0	0.0	0%	0.0	37.2	4%	0	1.3	**9.4**	**28.2**
3.0	sda3	0.0	0.0	0.0	0%	0.0	0.0	1.0	4.0	0.0	0%	0.0	22.7	2%	0	1.0	**0.0**	**22.7**
3.0	dm-1	0.0	0.0	0.0	0%	0.0	0.0	0.0	0.0	0.0	0%	0.0	0.0	2%	0	0.0	**0.0**	**0.0**
3.0	dm-2	0.0	0.0	0.0	0%	0.0	0.0	0.7	4.0	0.0	0%	0.0	30.0	2%	0	0.7	**0.0**	**30.0**
3.0	sda	0.0	0.0	0.0	0%	0.0	0.0	1.3	6.0	0.0	50%	0.0	10.1	4%	2	1.3	**0.7**	**14.6**
3.0	sda3	0.0	0.0	0.0	0%	0.0	0.0	1.0	8.0	0.0	57%	0.0	1.1	1%	1	1.0	**-0.8**	**6.3**
3.0	dm-0	0.0	0.0	0.0	0%	0.0	0.0	0.7	4.0	0.0	0%	0.0	0.0	1%	2	0.7	**0.0**	**18.0**
3.0	dm-1	0.0	0.0	0.0	0%	0.0	0.0	1.3	4.0	0.0	0%	0.0	0.0	1%	1	1.3	**-1.8**	**9.0**
3.0	dm-2	0.0	0.0	0.0	0%	0.0	0.0	1.0	4.0	0.0	0%	0.0	27.0	3%	0	1.0	**0.0**	**27.0**
3.0	sda	0.0	0.0	0.0	0%	0.0	0.0	2.3	3.4	0.0	0%	0.1	43.4	5%	0	2.3	**26.4**	**20.0**
3.0	sda3	0.0	0.0	0.0	0%	0.0	0.0	1.7	4.8	0.0	0%	0.1	33.4	3%	0	1.7	**12.1**	**20.6**
3.0	dm-0	0.0	0.0	0.0	0%	0.0	0.0	0.3	4.0	0.0	0%	0.1	191.0	3%	0	0.3	**-211.0**	**92.0**
3.0	dm-1	0.0	0.0	0.0	0%	0.0	0.0	0.0	0.0	0.0	0%	0.0	0.0	3%	0	0.0	**0.0**	**0.0**
3.0	dm-2	0.0	0.0	0.0	0%	0.0	0.0	0.7	4.0	0.0	0%	0.0	23.5	2%	0	0.7	**0.0**	**23.5**

pt-diskstats

- **qtime (milliseconds) – !iostat avgqu-sz**

```
delta[time_in_queue(f11)] /
(delta[read_IOs(f1) + read_merges(f2) + write_IOs(f5) +
write_merges(f6)] + delta[in_flight(f9)])
- delta[io_ticks(f10)] /
(delta[read_IOs(f1) + read_merges(f2) + write_IOs(f5) +
write_merges(f6)])
```

- **stime (milliseconds) – !iostat svctm**

```
delta[io_ticks(f10)] /
(delta[read_IOs(f1) + read_merges(f2) + write_IOs(f5) +
write_merges(f6)])
```

An example using iostat

```
[ben.mildren@316403-db7 ~]$ iostat -dx 5
Linux 2.6.18-194.17.1.el5 (xxxx)       04/25/2013

....

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               0.00     4.60    0.00   16.80     0.00    85.60    10.19     0.06    3.29    0.00    3.29   0.06   0.10
sdb            7607.00     5.20  253.60   23.40 31467.20   114.40   228.03     0.86    3.09    2.93    4.86   2.68  74.10
dm-0              0.00     0.00    0.00    0.40     0.00     1.60     8.00     0.00    4.00    0.00    4.00   2.00   0.08
dm-1              0.00     0.00    0.00   28.20     0.00   112.80     8.00     0.11    4.07    0.00    4.07   0.04   0.12
dm-2              0.00     0.00  374.80    0.00 31441.60     0.00   167.78     0.79    2.11    2.11    0.00   1.98  74.18
dm-3              0.00     0.00 7860.40    0.40 31441.60     1.60     8.00    23.21    2.95    2.95    4.00   0.09  74.16
dm-4              0.00     0.00    0.00    0.00     0.00     0.00     0.00     0.00    0.00    0.00    0.00   0.00   0.00

....
```

RAID Controller CLIs

- Adaptec

  ```
  arcconf -?
  ```

- Dell

  ```
  omreport -?
  ```

- HP Smart Array

  ```
  hpacucli
  Type "help" for a list of supported commands.
  Type "exit" to close the console.
  ```

- LSI

  ```
  MegaCli -?
  ```

- Oracle

  ```
  raidconfig -?
  ```

RAID Controller CLIs

- In this case it's a Dell server and controller

```
omreport storage controller
Controller  PERC 6/i Integrated (Embedded)

Controllers
ID                                              : 0
Status                                          : Ok
Name                                            : PERC 6/i Integrated
...
State                                           : Ready
Firmware Version                                : 6.2.0-0013
...
Driver Version                                  : 00.00.04.17-RH1
...
Number of Connectors                            : 2
...
Cache Memory Size                               : 256 MB
...
```

RAID Controller CLIs

- /dev/sdb is RAID-5 SAS HDDs

```
[root@316402-db6 srvadmin]# omreport storage vdisk
List of Virtual Disks in the System

...
ID                          : 1
Status                      : Ok
...
Layout                      : RAID-5
Size                        : 836.63 GB (898319253504 bytes)
Device Name                 : /dev/sdb
Bus Protocol                : SAS
Media                       : HDD
Read Policy                 : No Read Ahead
Write Policy                : Write Back
...
Stripe Element Size         : 64 KB
Disk Cache Policy           : Disabled
```

RAID Controller CLIs

- /dev/sdb is RAID-5 SAS HDDs

```
[root@316402-db6 srvadmin]# omreport storage pdisk controller=0 vdisk=1
List of Physical Disks on Controller PERC 6/i Integrated (Embedded)

Controller PERC 6/i Integrated (Embedded)
ID                      : 0:0:2
...
State                   : Online
Failure Predicted       : No
...
Bus Protocol            : SAS
Media                   : HDD
...
Capacity                : 136.13 GB (146163105792 bytes)
...
Vendor ID               : DELL
Product ID              : ST3146356SS
...
```

Calculating IOPS

- ST3146356SS - Cheetah 15K.6 SAS
  (Googled - http://www.datasheets.pl/hard_drives/ST3450856SS.pdf)

  Disk rotation speed – 15k rpm
  Avg rotational latency – 2.0ms = (1 / (15000/60)) * 0.5 * 1000
  Avg read access time – 3.4ms
  Avg write access time – 3.9ms

- Looking at *omreport storage vdisk*
  Layout – RAID-5

- Counting disks in *omreport storage pdisk controller=0 vdisk=1*
  # Disks – 4

Calculating IOPS

- http://www.techrepublic.com/blog/datacenter/calculate-iops-in-a-storage-array/2182

  “To calculate the IOPS range, use this formula: Average IOPS: Divide 1 by the sum of the average latency in ms and the average seek time in ms (1 / (average latency in ms + average seek time in ms).”

- Using gathered data:

  1 / (2ms + ((3.4ms +3.9ms)/2))

  1 / (0.002 + ((0.0034+0.0039)/2)) = 177 iops (Single disk)

- This is inline with the earlier rough estimate of 175-200 iops from 15k rpm disk! Avg read/write access time are the only measures that should differ per model, rotational latency should be constant dependent on the disk rotation speed, so the estimates should be reasonable.

Calculating multi disk array IOPS

- http://www.techrepublic.com/blog/datacenter/calculate-iops-in-a-storage-array/2182

  “(Total Workload IOPS * Percentage of workload that is read operations) + (Total Workload IOPS * Percentage of workload that is *write* operations * RAID IO Penalty”

- Using gathered data:

  ((4 * 177) * 0.9) + (((4 * 177) * 0.1) / 4) = 654.9 iops

- This is doesn't account for the controller cache, so should be a worst case limit.

I/O Impact		
RAID level	**Read**	**Write**
RAID 0	1	1
RAID 1 (and 10)	1	2
RAID 5	1	4
RAID 6	1	6

Picture credit also http://www.techrepublic.com/blog/datacenter/calculate-iops-in-a-storage-array/2182

Calculating throughput

- Formula to calculate maximum throughput

  MB/s = IOPS * KB per IO / 1024

- Using gathered data for IOPs, and estimates for KB per IO:

  654.9 * 8 / 1024 = 5.1 mb/s

  654.9 * 16 / 1024 = 10.2 mb/s

  654.9 * 64 / 1024 = 40.9 mb/s

  654.9 * 128 / 1024 = 81.9 mb/s

- Where KB per IO fits on this scale depends on how random vs sequential the IO is.

An example using iostat

```
[ben.mildren@316403-db7 ~]$ iostat -dx 5
Linux 2.6.18-194.17.1.el5 (xxxx)        04/25/2013

....
```

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	0.00	4.60	0.00	16.80	0.00	85.60	10.19	0.06	3.29	0.00	3.29	0.06	0.10
sdb	**7607.00**	**5.20**	**253.60**	**23.40**	**31467.20**	**114.40**	**228.03**	**0.86**	**3.09**	**2.93**	**4.86**	**2.68**	**74.10**
dm-0	0.00	0.00	0.00	0.40	0.00	1.60	8.00	0.00	4.00	0.00	4.00	2.00	0.08
dm-1	0.00	0.00	0.00	28.20	0.00	112.80	8.00	0.11	4.07	0.00	4.07	0.04	0.12
dm-2	0.00	0.00	374.80	0.00	31441.60	0.00	167.78	0.79	2.11	2.11	0.00	1.98	74.18
dm-3	0.00	0.00	7860.40	0.40	31441.60	1.60	8.00	23.21	2.95	2.95	4.00	0.09	74.16
dm-4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

```
....
```

Observations:

- ~275 IOPs well below estimated limit of ~650 IOPs
- Average queue size (avgqu-sz) is low.
- At ~30mb/s (rkB/s + wkB/s), throughput will not be saturating the controller, rearranging the throughput formula we can see IOPs are about 114kb per IO which leans to a more sequential workload.
- Latency (read/write average wait time) is inline with drive manufacturer expectations.

An example using iostat

```
[ben.mildren@316403-db7 ~]$ iostat -dx 5
Linux 2.6.18-194.17.1.el5 (xxxx)        04/25/2013

....
```

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	0.00	4.60	0.00	16.80	0.00	85.60	10.19	0.06	3.29	0.00	3.29	0.06	0.10
sdb	**7607.00**	**5.20**	**253.60**	**23.40**	**31467.20**	**114.40**	**228.03**	**0.86**	**3.09**	**2.93**	**4.86**	**2.68**	**74.10**
dm-0	0.00	0.00	0.00	0.40	0.00	1.60	8.00	0.00	4.00	0.00	4.00	2.00	0.08
dm-1	0.00	0.00	0.00	28.20	0.00	112.80	8.00	0.11	4.07	0.00	4.07	0.04	0.12
dm-2	0.00	0.00	374.80	0.00	31441.60	0.00	167.78	0.79	2.11	2.11	0.00	1.98	74.18
dm-3	0.00	0.00	7860.40	0.40	31441.60	1.60	8.00	23.21	2.95	2.95	4.00	0.09	74.16
dm-4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

```
....
```

Observations:

- Average request size (avgrq-sz) is ~114k (matches throughput calc), so the load is probably not being generated by MySQL.
- High number of merges, not a bad thing, but might want to investigate why..

  (In this case they were caused by an LVM Snapshot being read during a backup).

Thank you – Q&A

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