Linux for System z
Performance Tools for Problem Determination

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Agenda

- Introduction
- Start the analysis
- Formulate a theory
- Looking into the problem area
  - CPU related issues
  - Memory related issues
  - I/O related issues
  - Networking related issues
- A look at monitoring

What this is not about

- Functional problems / crashes

General thoughts on performance analysis

- Things that are always to consider
  - Monitoring will impact the system
  - Most data gathering averages over a period of time
    - → this flattens peaks
  - Define the problem
    - which parameter(s) from the application/system indicates the problem
    - which range is considered bad, what is considered good
  - Monitor the good case and save the results
    - comparison good vs. bad can save a lot of time
- Staged approach saves a lot of work
  - Try to use general tools to isolate the area of the issue
  - Create theories and try to quickly verify/falsify them
  - Use advanced tools to debug the identified area

Start the analysis

"Taking a quick look"

The “ps” tool

- Reports a snapshot of the currently running processes
- Usage: “`ps axlf`”, many more options available
- Example output

```
#> ps axlf
F   UID   PID  PPID PRI  NI    VSZ   RSS WCHAN  STAT TTY        TIME COMMAND
1     0     2     0  20   0      0     0 kthrea S    ?          0:00 [kthreadd]
1     0     3     2  20   0      0     0 smpboo S    ?          0:00  \_ [ksoftirqd/0]
5     0     4     2  20   0      0     0 worker S    ?          0:00  \_ [kworker/0:0]
1     0     5     2   0 -20      0     0 worker S<   ?          0:00  \_ [kworker/0:0H]
...
4     0     1     0  20   0   9672  5096 SyS_ep Ss   ?          0:01 /sbin/init
4     0  2023     1  20   0   3584  1400 hrtime Ss   ?          0:00 /usr/sbin/crond -n
4     0  2024     1  20   0   2840   892 pause  Ss   ?          0:00 /usr/sbin/atd -f
...
4     0  2280     1  20   0  10892  3344 poll_s Ss   ?          0:00 /usr/sbin/sshd -D
4     0  2316  2280  20   0  14472  4700 poll_s Ss   ?          0:00  \_ sshd: root@pts/0
4     0  2318  2316  20   0 106392  2216 wait   Ss   pts/0      0:00      \_ -bash
0     0  2350  2318  20   0 105576  1056 -      R+   pts/0      0:00          \_ ps axlf
1     0  2351  2318  20   0 106392   796 sleep_ D+   pts/0      0:00          \_ -bash
...
0     0  2368  2318  20   0   2192   360 -      R    pts/0    110:04 /usr/bin/app
...
```

The “top” tool

- Shows resource usage on process level
- Usage: “`top -b -d [interval in sec] > [outfile]`”
- Shows
  - CPU utilization
  - Detailed memory usage

- Hints
  - Parameter -b enables to write the output for each interval to a file
  - Use -p [pid1, pid2, ...] to reduce the output to the processes of interest
  - Configure displayed columns using 'f' key on the running top instance
  - Use the 'W' key to write current configuration to ~/.toprc
    - becomes the default

The “top” tool

- Output example

```
top - 11:12:52 up  1:11,  3 users,  load average: 1.21, 1.61, 2.03
Tasks:  53 total,   5 running,  48 sleeping,   0 stopped,   0 zombie
Cpu(s):  3.0%us,  5.9%sy,  0.0%ni, 79.2%id,  9.9%wa,  0.0%hi,  1.0%si,  1.0%st
Mem:   5138052k total,   801100k used,  4336952k free,   447868k buffers
Swap:       88k total,        0k used,       88k free,   271436k cached

 PID USER      PR  NI  VIRT  RES  SHR S %CPU %MEM    TIME+  P SWAP DATA WCHAN     COMMAND
3224 root      18   0  1820  604  444 R  2.0  0.0   0:00.56 0 1216  252 -         dbench
3226 root      18   0  1820  604  444 R  2.0  0.0   0:00.56 0 1216  252 -         dbench
2737 root      16   0  9512 3228 2540 R  1.0  0.1   0:00.46 0 6284  868 -         sshd
3225 root      18   0  1820  604  444 R  1.0  0.0   0:00.56 0 1216  252 -         dbench
3230 root      16   0  2652 1264  980 R  1.0  0.0   0:00.01 0 1388  344 -         top
   1 root      16   0   848  304  256 S  0.0  0.0   0:00.54 0  544  232 select    init
   2 root      RT   0     0    0    0 S  0.0  0.0   0:00.00 0    0    0 migration migration/0
   3 root      34  19     0    0    0 S  0.0  0.0   0:00.00 0    0    0 ksoftirqd ksoftirqd/0
   4 root      10  -5     0    0    0 S  0.0  0.0   0:00.13 0    0    0 worker_th events/0
   5 root      20  -5     0    0    0 S  0.0  0.0   0:00.00 0    0    0 worker_th khelper
```

- Hints
  - virtual memory: VIRT = SWAP + RES unit KB
  - physical memory used: RES = CODE + DATA unit KB
  - shared memory: SHR unit KB
  - The “htop” tool is an alternative “top” with extra features

The “hyptop” tool

- Show hypervisor performance data on System z
  - Check CPU and overhead statistics of your and sibling images
- Usage: “`hyptop`”
- Shows
  - CPU load and management overhead
  - Memory usage (only under z/VM)
  - Can show image overview or single image details
- Hints
  - Good “first view” tool for a look outside of a single image
  - Requirements
    - For z/VM the guest needs class B
    - For LPAR “Global performance data control” needs to be enabled

The “hyptop” tool

memuse = resident

Why are exactly 4 CPUs used in all 6 CPU guests

All these do not fully utilize their 2 CPUs

No peaks in service guests

LPAR images would see other LPARs

service guest weights

```
11:12:56 CPU-T: UN(64)
system    #cpu      cpu   Cpu+   online memuse memmax wcur
(str)      (#)      (%)   (hm)    (dmh)  (GiB)  (GiB)  (#)
R3729003     6   399.11   2:24 0:03:05  11.94  12.00  100
R3729004     6   399.07   2:24 0:03:05  11.94  12.00  100
R3729001     6   398.99   2:26 0:03:09  11.95  12.00  100
R3729005     6   398.76   2:24 0:03:05  11.94  12.00  100
R3729009     4   398.62   2:22 0:03:05   4.20   6.00  100
R3729008     4   398.49   2:22 0:03:05   4.21   6.00  100
R3729007     4   398.39   2:21 0:03:05   4.18   6.00  100
R3729010     4   398.02   2:21 0:03:05   4.18   6.00  100
R3729002     6   397.99   2:24 0:03:05  11.94  12.00  100
R3729006     4   393.09   2:21 0:03:05   4.17   6.00  100
R3729012     2   117.37   0:43 0:03:05   0.25   2.00  100
R3729014     2   117.27   0:44 0:03:05   0.25   2.00  100
R3729011     2   117.13   0:43 0:02:37   0.25   2.00  100
R3729013     2   117.08   0:43 0:03:05   0.25   2.00  100
R3729015     2   116.63   0:43 0:03:05   0.25   2.00  100
VMSERVU      1     0.00   0:00 0:03:10   0.01   0.03 1500
VMSERVP      1     0.00   0:00 0:03:10   0.01   0.06 1500
VMSERVR      1     0.00   0:00 0:03:10   0.01   0.03 1500
RACFVM       1     0.00   0:00 0:03:10   0.01   0.02  100
OPERSYMP     1     0.00   0:00 0:03:10   0.01   0.03  100
TCPIP        1     0.00   0:00 0:03:10   0.01   0.12 3000
DTCVSW2      1     0.00   0:00 0:03:10   0.01   0.03  100
OPERATOR     1     0.00   0:00 0:03:10   0.00   0.03  100
RSCS         1     0.00   0:00 0:03:09   0.00   0.03  100
RSCSDNS      1     0.00   0:00 0:03:10   0.00   0.03  100
AUTOVM       1     0.00   0:00 0:03:10   0.00   0.03  100
GCS          1     0.00   0:00 0:03:10   0.00   0.02  100
LGLOPR       1     0.00   0:00 0:03:10   0.00   0.03  100
DIRMAINT     1     0.00   0:00 0:30:10   0.01   0.03  100
DTCVSW1      1     0.00   0:00 0:30:10   0.01   0.03  100
```

The “vmstat” tool

- Report virtual memory statistics
- Usage: “`vmstat [interval in sec]`”
- Shows
  - Data per time interval
  - CPU utilization
  - Disk I/O
  - Memory usage / swapping
- Output example

```
#> vmstat 1
procs -----------memory---------- ---swap-- -----io---- -system-- -----cpu------
 r  b   swpd   free   buff  cache    si   so    bi    bo   in   cs us sy id wa st
 2  2      0 4415152  64068 554100    0    0     4 63144  350   55 29 64  0  3  4
 3  0      0 4417632  64832 551272    0    0     0   988  125   60 32 67  0  0  1
 3  1      0 4415524  68100 550068    0    0     0  5484  212   66 31 64  0  4  1
 3  0      0 4411804  72188 549592    0    0     0  8984  230   42 32 67  0  0  1
```

- Hints
  - Shared memory usage is listed under 'cache'

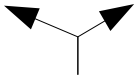
The “pidstat” tool

- Report statistics for Linux tasks
  - Identify processes with peak activity
- Usage: “`pidstat [-w | -r | -d]`”
- Shows
  - `-w` context switching activity and if it was voluntary
  - `-r` memory statistics, especially minor/major faults per process
  - `-d` disk throughput per process
- Hints
  - Also useful if run as background log due to its low overhead
    - Good extension to sadc in systems running different applications/services
  - `-p <pid>` can be useful to track activity of a specific process

The “pidstat” tool

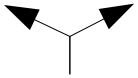
- Example output

```
12:46:18 PM       PID   cswch/s nvcswch/s  Command
12:46:18 PM         3      2.39      0.00  smbd
12:46:18 PM         4      0.04      0.00  sshd
12:46:18 PM      1073    123.42    180.18  Xorg
```



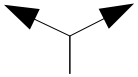
Voluntarily / Involuntary

```
12:47:51 PM       PID  minflt/s  majflt/s     VSZ    RSS   %MEM  Command
12:47:51 PM       985      0.06      0.00   15328   3948   0.10  smbd
12:47:51 PM       992      0.04      0.00    5592   2152   0.05  sshd
12:47:51 PM      1073    526.41      0.00 1044240 321512   7.89  Xorg
```



Faults per process

```
12:49:18 PM       PID   kB_rd/s   kB_wr/s kB_ccwr/s  Command
12:49:18 PM       330      0.00      1.15      0.00  sshd
12:49:18 PM      2899      4.35      0.09      0.04  notes2
12:49:18 PM      3045     23.43      0.01      0.00  audacious2
```



How much KB disk I/O per process

Formulate a theory

"Make a wild guess"

Formulate a theory

- Identify the most likely problem area
  - CPU related
  - Memory related
  - I/O related
  - Networking related
  - or a combination of several factors
- If the first look did not show anything obvious use monitoring
  - Needs preparation to capture the event of interest, e.g. at 4pm
  - Usually a lot of data is generated that needs to be analysed
  - Monitoring will impact your system

CPU related issues

"Who is stealing my CPU ?"

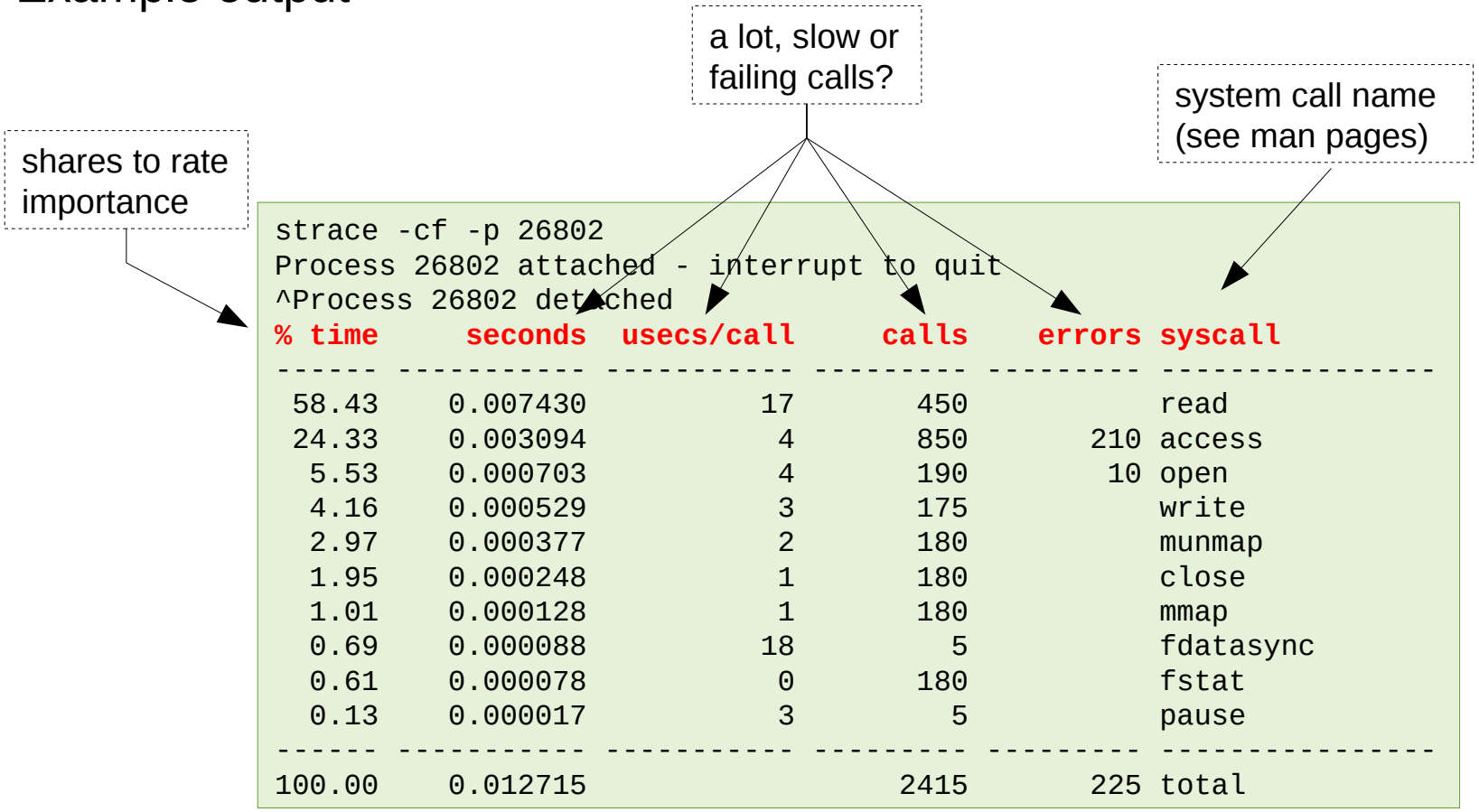
The “strace” tool

- Trace system calls and signals
- Usage: “`strace -p [process id]`”
- Shows
  - Identify kernel entries called more often or taking too long
    - Can be useful if you search for increased system time
  - Time in call (`-T`)
  - Relative timestamp (`-r`)

- Hints
  - High overhead, high detail tool which will slow down your application
  - Option “`-c`” allows medium overhead by just tracking counters and durations

The “strace” tool

- Example output



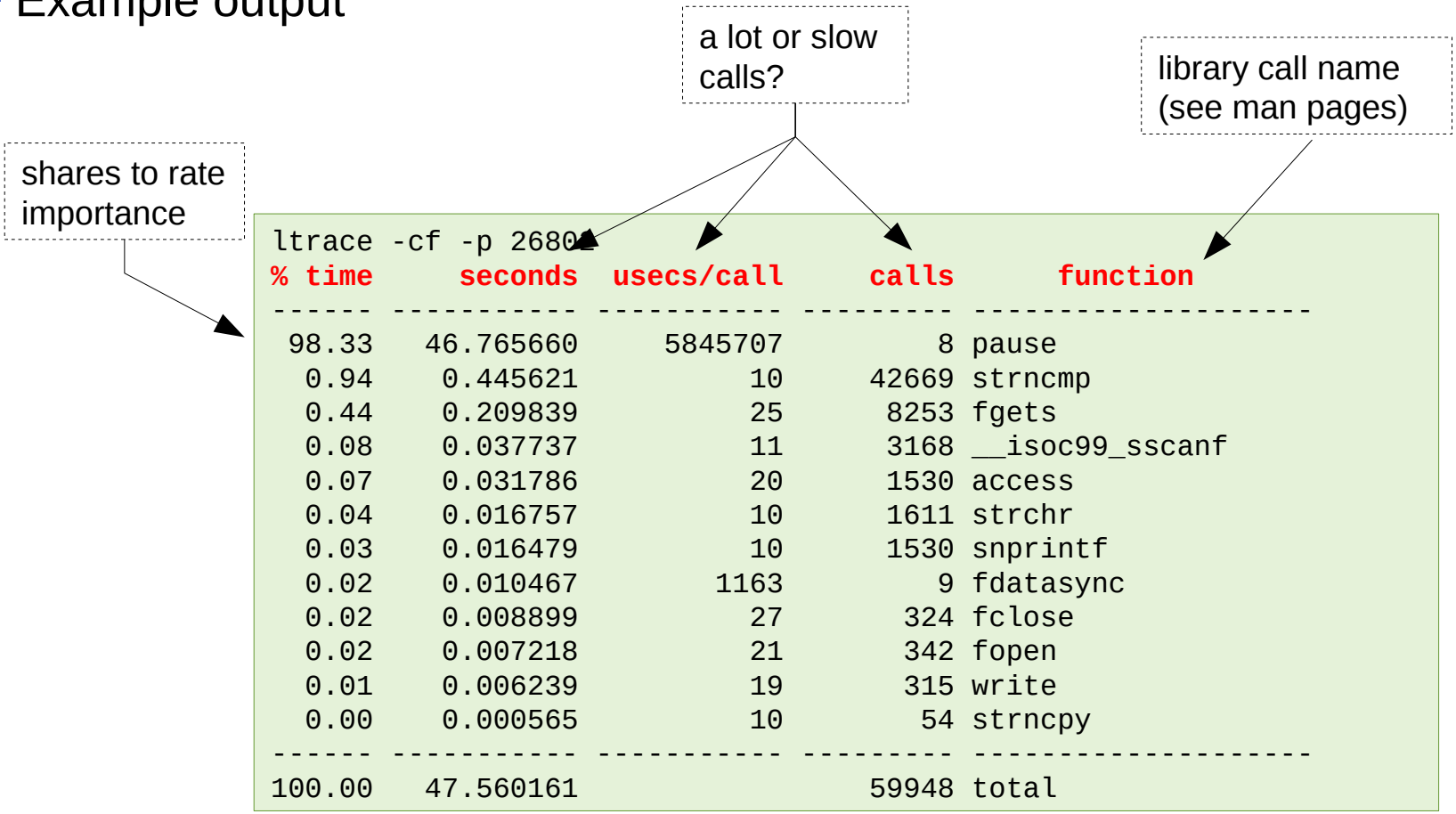

```
strace -cf -p 26802
Process 26802 attached - interrupt to quit
^Process 26802 detached
% time     seconds  usecs/call     calls    errors syscall
------ ----------- ----------- --------- --------- ----------------
 58.43    0.007430          17       450           read
 24.33    0.003094           4       850       210 access
  5.53    0.000703           4       190        10 open
  4.16    0.000529           3       175           write
  2.97    0.000377           2       180           munmap
  1.95    0.000248           1       180           close
  1.01    0.000128           1       180           mmap
  0.69    0.000088          18         5           fdatasync
  0.61    0.000078           0       180           fstat
  0.13    0.000017           3         5           pause
------ ----------- ----------- --------- --------- ----------------
100.00    0.012715                  2415       225 total
```

The “ltrace” tool

- A library call tracer
- Usage: “`ltrace -p [process id]`”
- Shows
  - Identify library calls that are too often or take too long
    - Good if you search for additional user time
    - Good if things changed after upgrading libs
  - Time in call (`-T`)
  - Relative timestamp (`-r`)
- Hints
  - High overhead, high detail tool which will slow down your application
  - Option “`-c`” allows medium overhead by just tracking counters and durations
  - Option “`-S`” allows to combine ltrace and strace

The “ltrace” tool

- Example output




```
ltrace -cf -p 2680
% time     seconds  usecs/call     calls      function
------ ----------- ----------- --------- --------------------
 98.33   46.765660     5845707         8 pause
  0.94    0.445621          10     42669 strncmp
  0.44    0.209839          25      8253 fgets
  0.08    0.037737          11      3168 __isoc99_sscanf
  0.07    0.031786          20      1530 access
  0.04    0.016757          10      1611 strchr
  0.03    0.016479          10      1530 snprintf
  0.02    0.010467        1163         9 fdatasync
  0.02    0.008899          27       324 fclose
  0.02    0.007218          21       342 fopen
  0.01    0.006239          19       315 write
  0.00    0.000565          10        54 strncpy
------ ----------- ----------- --------- --------------------
100.00   47.560161                 59948 total
```

The “perf” tool

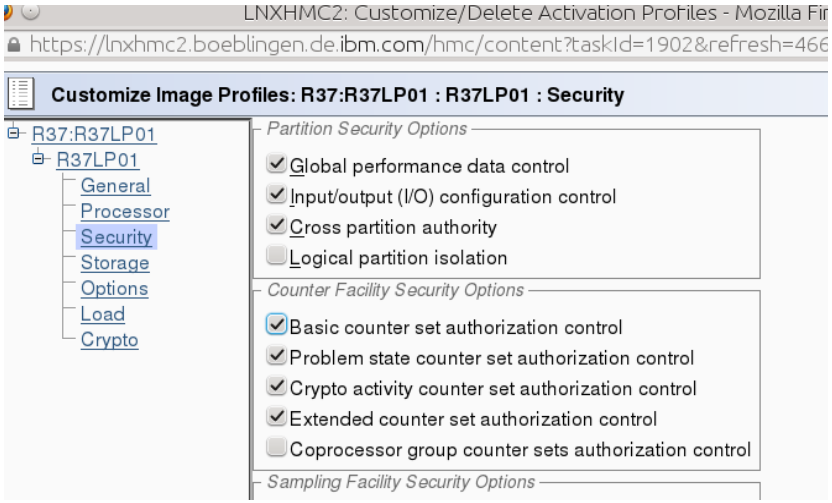
- Performance analysis tools for Linux
  - Get detailed information where & why CPU is consumed
- Usage: “`perf top`”, “`perf stat <cmd>`”, “`perf record/perf diff`”
- Shows
  - Sampling for CPU hotspots
    - Annotated source code along hotspots, list functions according to their usage
  - CPU event counters
  - Kernel tracepoints
- Hints
  - Without HW support only userspace can be reasonably profiled
  - “successor” of oprofile that is available with HW support (SLES11-SP2)
  - Perf HW is upstream, wait for next distribution releases
  - Won't help with I/O wait or CPU stalls

The “perf” tool

- Example output (perf diff)

```
# Baseline  Delta                          Symbol
# ........ .........  ..................... ......
#
    12.14%     +8.07%  [kernel.kallsyms]   [k] lock_acquire
     8.96%     +5.50%  [kernel.kallsyms]   [k] lock_release
     4.83%     +0.38%  reaim               [.] add_long
     4.22%     +0.41%  reaim               [.] add_int
     4.10%     +2.49%  [kernel.kallsyms]   [k] lock_acquired
     3.17%     +0.38%  libc-2.11.3.so      [.] msort_with_tmp
     3.56%     -0.37%  reaim               [.] string_rtns_1
     3.04%     -0.38%  libc-2.11.3.so      [.] strncat
```

- Preparation
  - The cpu measurement facility needs to be enabled



Memory related issues

“Who is eating all the memory ?”

The “smem” tool

- Memory usage details per process/mapping
- Usage: `smem -tk -c "pid user command swap vss uss pss rss”`
  `smem -m -tk -c "map count pids swap vss uss rss pss avgrss avgpss"`
- Package: http://www.selenic.com/smem/
- Shows
  - Pid, user, Command or Mapping, Count, Pid
  - Memory usage in categories vss, uss, rss, pss and swap
- Hints
  - Has visual output (pie charts) and filtering options as well
  - No support for huge pages or transparent huge pages (kernel interface missing)

The “smem” tool

- Example output

```
# smem -tk -c "pid user command swap vss uss pss rss”
  PID User     Command                         Swap      VSS      USS      PSS      RSS
 1860 root     /sbin/agetty -s sclp_line0         0     2.1M    92.0K   143.0K   656.0K
 1861 root     /sbin/agetty -s ttysclp0 11        0     2.1M    92.0K   143.0K   656.0K
  493 root     /usr/sbin/atd -f                   0     2.5M   172.0K   235.0K   912.0K
 1882 root     /sbin/udevd                        0     2.8M   128.0K   267.0K   764.0K
 1843 root     /usr/sbin/crond -n                 0     3.4M   628.0K   693.0K     1.4M
  514 root     /bin/dbus-daemon --system -        0     3.2M   700.0K   771.0K     1.5M
  524 root     /sbin/rsyslogd -n -c 5             0   219.7M   992.0K     1.1M     1.9M
 2171 root     ./hhhptest                         0     5.7G     1.0M     1.2M     3.2M
 1906 root     -bash                              0   103.8M     1.4M     1.5M     2.1M
 2196 root     ./hhhptest                         0     6.2G     2.0M     2.2M     3.9M
 1884 root     sshd: root@pts/0                   0    13.4M     1.4M     2.4M     4.2M
    1 root     /sbin/init                         0     5.8M     2.9M     3.0M     3.9M
 2203 root     /usr/bin/python /usr/bin/sm        0   109.5M     6.1M     6.2M     6.9M
```

- How much of a process is:
  - Swap - Swapped out
  - VSS - Virtually allocated
  - USS - Really unique
  - RSS - Resident
  - PSS - Resident accounting a proportional part of shared memory

The “smem” tool

- Example output

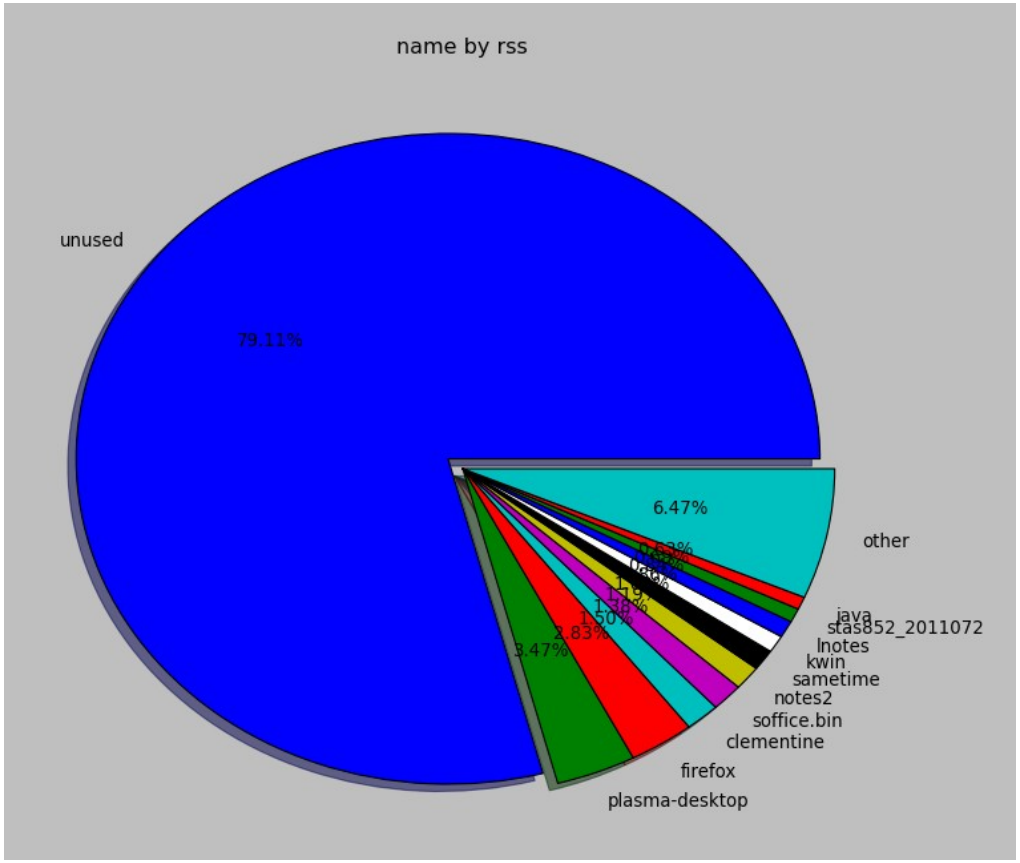
```
# smem -m -tk -c "map count pids swap vss uss rss pss avgrss avgpss"

Map                                    Count  PIDs      Swap       VSS       USS       RSS       PSS    AVGRSS    AVGPSS
[stack:531]                                1     1         0      8.0M         0         0         0         0         0
[vdso]                                    25    25         0    200.0K         0    132.0K         0     5.0K         0
/dev/zero                                  2     1         0      2.5M      4.0K      4.0K      4.0K      4.0K      4.0K
/usr/lib64/sasl2/libsasldb.so.2.0.23       2     1         0     28.0K      4.0K      4.0K      4.0K      4.0K      4.0K
/bin/dbus-daemon                           3     1         0    404.0K    324.0K    324.0K    324.0K    324.0K    324.0K
/usr/sbin/sshd                             6     2         0      1.2M    248.0K    728.0K    488.0K    364.0K    244.0K
/bin/systemd                               2     1         0    768.0K    564.0K    564.0K    564.0K    564.0K    564.0K
/bin/bash                                  2     1         0      1.0M    792.0K    792.0K    792.0K    792.0K    792.0K
[stack]                                   25    25         0      4.1M    908.0K    976.0K    918.0K     39.0K     36.0K
/lib64/libc-2.14.1.so                     75    25         0     40.8M    440.0K      9.3M      1.2M    382.0K     48.0K
/lib64/libcrypto.so.1.0.0j                 8     4         0      7.0M    572.0K      2.0M      1.3M    501.0K    321.0K
[heap]                                    16    16         0      8.3M      6.4M      6.9M      6.6M    444.0K    422.0K
<anonymous>                              241    25         0     55.7G     20.6M     36.2M     22.3M      1.4M    913.0K
```

- How much of a process is:
  - Swap - Swapped out
  - VSS - Virtually allocated
  - USS - Really unique
  - RSS - Resident
  - PSS - Resident accounting a proportional part of shared memory
  - Averages as there can be multiple mappers

The “smem” tool

- Example of a memory distribution Visualization (many options)
- Warning in regard to monitoring the /proc/<pid>/smaps interface is expensive



The “/proc/meminfo” interface

- How the kernel has allocated the memory

```
# cat /proc/meminfo
MemTotal:         889520 kB
MemFree:          749820 kB
Buffers:           10956 kB
Cached:            58844 kB
SwapCached:            0 kB
Active:            27140 kB
Inactive:          55760 kB
Active(anon):      13292 kB
Inactive(anon):     1184 kB
Active(file):      13848 kB
Inactive(file):    54576 kB
Unevictable:           0 kB
Mlocked:               0 kB
SwapTotal:       1048556 kB
SwapFree:        1048556 kB
Dirty:                 0 kB
Writeback:             0 kB
AnonPages:         13204 kB
Mapped:             7528 kB
```

```
Shmem:              1352 kB
Slab:              39544 kB
SReclaimable:      18200 kB
SUnreclaim:        21344 kB
KernelStack:        2208 kB
PageTables:          608 kB
NFS_Unstable:          0 kB
Bounce:                0 kB
WritebackTmp:          0 kB
CommitLimit:     1493316 kB
Committed_AS:      52680 kB
VmallocTotal:   130023424 kB
VmallocUsed:      118616 kB
VmallocChunk:   129903444 kB
AnonHugePages:         0 kB
HugePages_Total:       0
HugePages_Free:        0
HugePages_Rsvd:        0
HugePages_Surp:        0
Hugepagesize:       1024 kB
```

The “slabtop” tool

- Display kernel slab cache information in real time
- Usage: “`slabtop`”
- Shows
  - Active / Total object number/size
  - Objects per Slab
  - Object Name and Size
  - Objects per Slab
- Hints
  - Option -o is used for one time output e.g. to gather debug data
  - Despite slab/slob/slub in kernel its always slabtop

The “slabtop” tool

- Example output

```
 Active / Total Objects (% used)    : 2436408 / 2522983 (96.6%)
 Active / Total Slabs (% used)      : 57999 / 57999 (100.0%)
 Active / Total Caches (% used)     : 75 / 93 (80.6%)
 Active / Total Size (% used)       : 793128.19K / 806103.80K (98.4%)
 Minimum / Average / Maximum Object : 0.01K / 0.32K / 8.00K

  OBJS ACTIVE  USE OBJ SIZE  SLABS OBJ/SLAB CACHE SIZE NAME
578172 578172 100%    0.19K  13766       42    110128K dentry
458316 458316 100%    0.11K  12731       36     50924K sysfs_dir_cache
368784 368784 100%    0.61K   7092       52    226944K proc_inode_cache
113685 113685 100%    0.10K   2915       39     11660K buffer_head
113448 113448 100%    0.55K   1956       58     62592K inode_cache
111872  44251  39%    0.06K   1748       64      6992K kmalloc-64
 54688  50382  92%    0.25K   1709       32     13672K kmalloc-256
 40272  40239  99%    4.00K   5034        8    161088K kmalloc-4096
 39882  39882 100%    0.04K    391      102      1564K ksm_stable_node
 38505  36966  96%    0.62K    755       51     24160K shmem_inode_cache
 37674  37674 100%    0.41K    966       39     15456K dm_rq_target_io
```

How is kernel memory managed by the sl[auo]b allocator used

- Named memory pools or generic kmalloc pools
- Active/total objects and their size
- growth/shrinks of caches due to workload adaption

I/O related issues

"Why are disk always to slow?"

The “iostat” tool

- Report input/output statistics for devices and partitions
- Usage: “`iostat -xtdk [interval in sec]`”
- Shows
  - Throughput
  - Request merging
  - Device queue information
  - Service times
- Hints
  - Most critical parameter often is *await*
    - average time (in milliseconds) for I/O requests issued to the device to be served.
    - includes the time spent by the requests in queue and the time spent servicing them.
  - Also suitable for network file systems

The “iostat” tool

- Example output

```
Time: 10:56:35 AM
Device:         rrqm/s   wrqm/s     r/s     w/s    rkB/s    wkB/s avgrq-sz avgqu-sz   await  svctm  %util
dasda             0.19     1.45    1.23    0.74    64.43     9.29    74.88     0.01    2.65   0.80   0.16
dasdb             0.02   232.93    0.03    9.83     0.18   975.17   197.84     0.98   99.80   1.34   1.33

Time: 10:56:36 AM
Device:         rrqm/s   wrqm/s     r/s     w/s    rkB/s    wkB/s avgrq-sz avgqu-sz   await  svctm  %util
dasda             0.00     0.00    0.00    0.00     0.00     0.00     0.00     0.00    0.00   0.00   0.00
dasdb             0.00  1981.55    0.00  339.81     0.00  9495.15    55.89     0.91    2.69   1.14  38.83

Time: 10:56:37 AM
Device:         rrqm/s   wrqm/s     r/s     w/s    rkB/s    wkB/s avgrq-sz avgqu-sz   await  svctm  %util
dasda             0.00     0.00    0.00    0.00     0.00     0.00     0.00     0.00    0.00   0.00   0.00
dasdb             0.00  2055.00    0.00  344.00     0.00  9628.00    55.98     1.01    2.88   1.19  41.00
```

The “blktrace” tool

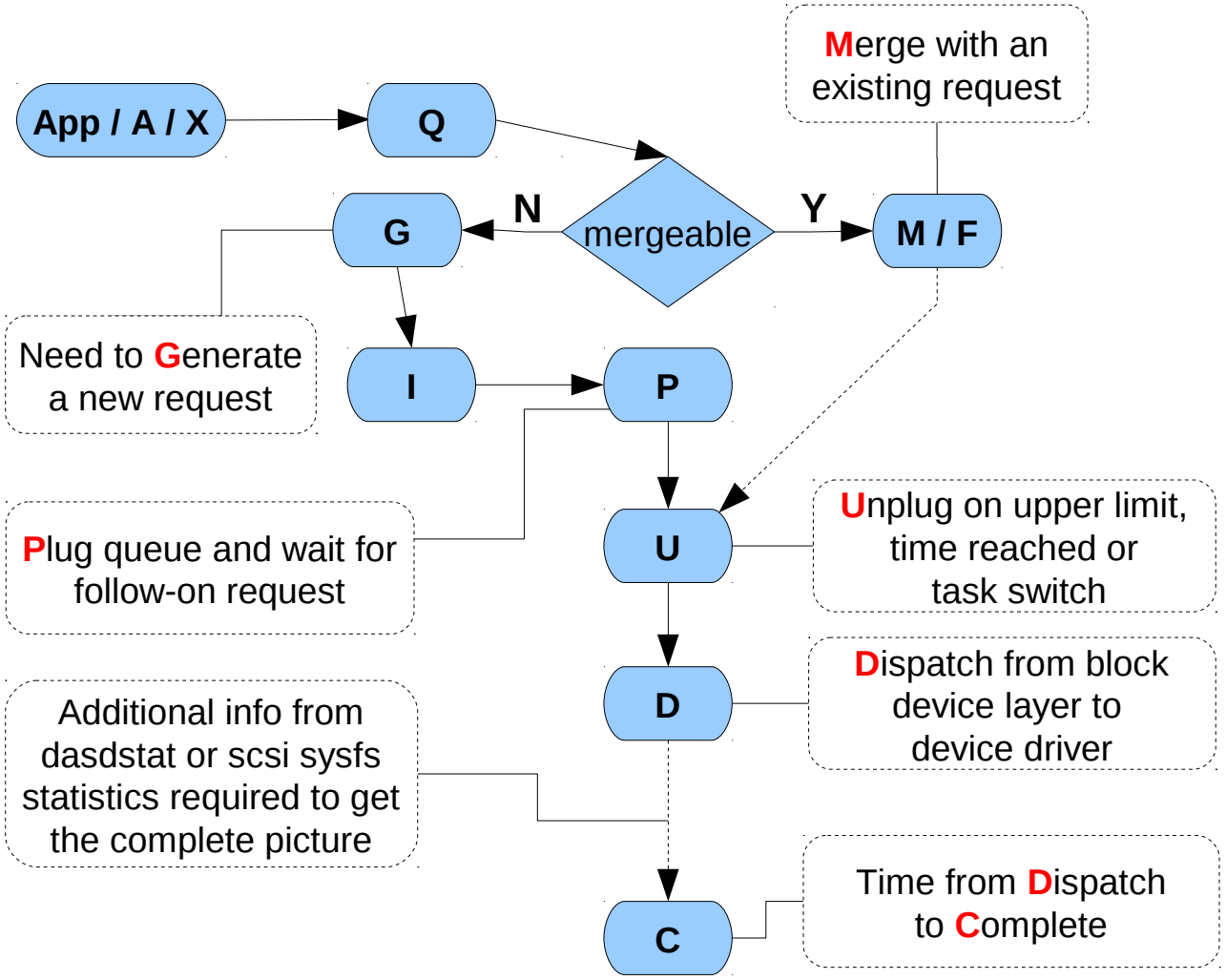
- Generate traces of the I/O traffic on block devices
- Usage: “`blktrace -d [device(s)]`”
  “`blktrace -st [commontracefilepart]`”
- Shows
  - Events like merging, request creation, I/O submission, I/O completion, ...
  - Timestamps and disk offsets for each event
  - Associated task and executing CPU
  - Application and CPU summaries
- Hints
  - Filter masks allow lower overhead if only specific events are of interest
  - Has an integrated client/server mode to stream data away
    - Avoids extra disk I/O on a system with disk I/O issues

The “blktrace” tool

- Often its easy to identify that I/O is slow
  → but where?
  → and why?

- Blocktrace allows to
  - Analyze Disk I/O characteristics like sizes and offsets
    - Maybe your I/O is split in a layer below
  - Analyze the timing with details about all involved Linux layers
    - Often useful to decide if HW or SW causes stalls
  - Summaries per CPU / application can identify imbalances

The “blktrace” tool – block device events (simplified)



A - remap
B - bounced
C - complete
D - issued
F - front merge
G - get request
I - inserted
M - back merge
P - plug
Q - queued
T - timer unplug
U - unplug
X - split

The “blktrace” tool

- Example output
  - The snippet shows a lot of 4k requests (8x512 byte sectors)
    - We expected the I/O to be 32k
  - Each one is dispatched separately (no merges)
    - This caused unnecessary overhead and slow I/O

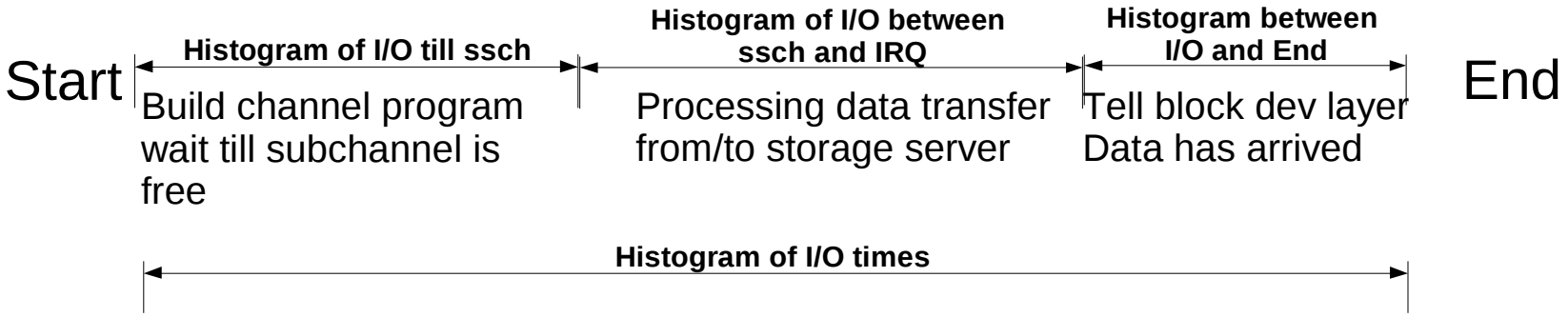
```
Maj/Min CPU   Seq-nr        sec.nsec   pid Action RWBS sect + size  map source / task
94,4     27        21     0.059363692 18994      A    R 20472832 + 8 <- (94,5) 20472640
94,4     27        22     0.059364630 18994      Q    R 20472832 + 8 [qemu-kvm]
94,4     27        23     0.059365286 18994      G    R 20472832 + 8 [qemu-kvm]
94,4     27        24     0.059365598 18994      I    R 20472832 + 8 (     312) [qemu-kvm]
94,4     27        25     0.059366255 18994      D    R 20472832 + 8 (     657) [qemu-kvm]
94,4     27        26     0.059370223 18994      A    R 20472840 + 8 <- (94,5) 20472648
94,4     27        27     0.059370442 18994      Q    R 20472840 + 8 [qemu-kvm]
94,4     27        28     0.059370880 18994      G    R 20472840 + 8 [qemu-kvm]
94,4     27        29     0.059371067 18994      I    R 20472840 + 8 (     187) [qemu-kvm]
94,4     27        30     0.059371473 18994      D    R 20472840 + 8 (     406) [qemu-kvm]
```

Action codes

The DASD statistics

- Collects statistics of I/O operations on DASD devices
- Usage:
  - enable: `echo on > /proc/dasd/statistics`
  - show:
    - Overall `cat /proc/dasd/statistics`
    - for individual DASDs `tunedasd -P /dev/dasda`
- Package: n/a for kernel interface, s390-tools for dasdstat
- Shows: various processing times

New Tool “dasdstat” available to handle that all-in-one



The FCP statistics

- Collects statistics of I/O operations on FCP devices on request base
- Usage:
  - CONFIG_STATISTICS=y must be enable for the kernel build
  - debugfs is mounted at /sys/kernel/debug/
  - for each FCP device there is a LUN directory
    `/sys/kernel/debug/statistics/zfcp-<device-bus-id>-<WWPN>-<LUN>`
  - to enable, do "`echo on=1 > definition`"
  - to disable, do "`echo on=0 > definition`"
  - to reset, do "`echo data=reset > definition`"
  - to view, do "`cat data`"
- Hint
  - FCP and DASD statistics are not directly comparable, because in the FCP case many I/O requests can be sent to the same LUN before the first response is given. There is a queue at FCP driver entry and in the storage server

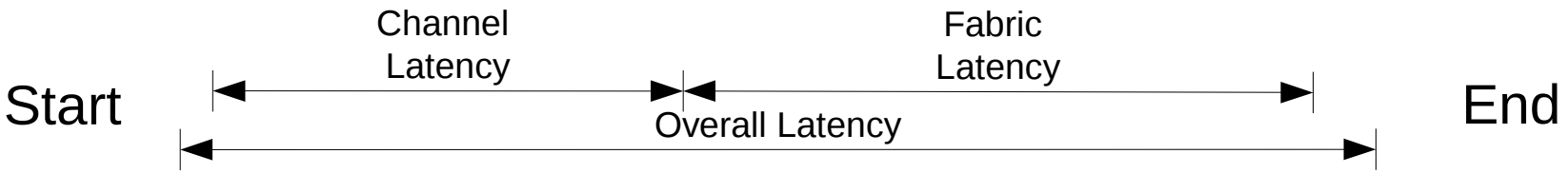
The FCP statistics

- Shows:
  - Request sizes in bytes (hexadecimal)
  - Channel latency Time spent in the FCP channel in nanoseconds
  - Fabric latency processing data transfer from/to storage server incl. SAN in nanoseconds
  - (Overall) latencies whole time spent in the FCP layer in milliseconds

  - Calculate the pass through time for the FCP layer as

```
pass through time = overall latency – (channel latency + fabric latency)
```

→ Time spent between the Linux device driver and FCP channel adapter inclusive in Hypervisor



IRQ statistics

- Condensed overview of IRQ activity
- Usage: `cat /proc/interrupts and cat /proc/softirqs`
- Shows
  - Which interrupts happen on which cpu
  - Where softirqs and tasklets take place
- Hints
  - Recent Versions (SLES11-SP2) much more useful due to better naming
  - If interrupts are unintentionally unbalanced
  - If the amount of interrupts matches I/O
    - This can point to non-working IRQ avoidance

IRQ statistics

- Example
  - Network focused on CPU zero (in this case unwanted)
  - Scheduler covered most of that avoiding idle CPU 1-3
  - But caused a lot migrations, IPI's and cache misses

```
           CPU0       CPU1       CPU2       CPU3
EXT:      21179      24235      22217      22959
I/O:    1542959     340076     356381     325691
CLK:      15995      16718      15806      16531   [EXT] Clock Comparator
EXC:        255        325        332        227   [EXT] External Call
EMS:       4923       7129       6068       6201   [EXT] Emergency Signal
TMR:          0          0          0          0   [EXT] CPU Timer
TAL:          0          0          0          0   [EXT] Timing Alert
PFL:          0          0          0          0   [EXT] Pseudo Page Fault
DSD:          0          0          0          0   [EXT] DASD Diag
VRT:          0          0          0          0   [EXT] Virtio
SCP:          6         63         11          0   [EXT] Service Call
IUC:          0          0          0          0   [EXT] IUCV
CPM:          0          0          0          0   [EXT] CPU Measurement
CIO:        163        310        269        213   [I/O] Common I/O Layer Interrupt
QAI:  1 541 773    338 857    354 728    324 110   [I/O] QDIO Adapter Interrupt
DAS:       1023        909       1384       1368   [I/O] DASD
[…] 3215, 3270, Tape, Unit Record Devices, LCS, CLAW, CTC, AP Bus, Machine Check
```

IRQ statistics

- Also softirqs can be tracked which can be useful to
  - check if tasklets execute as intended
  - See if network, scheduling and I/O behave as expected

	CPU0	CPU1	CPU2	CPU3
HI:	498	1522	1268	1339
TIMER:	5640	914	664	643
NET_TX:	15	16	52	32
NET_RX:	18	34	87	45
BLOCK:	0	0	0	0
BLOCK_IOPOLL:	0	0	0	0
TASKLET:	13	10	44	20
SCHED:	8055	702	403	445
HRTIMER:	0	0	0	0
RCU:	5028	2906	2794	2564

Networking related issues

“Is there anybody out there?”

The “netstat” tool

- Print network connections, routing tables, interface statistics and more
- Usage: “`netstat -eeapn`” list connections
  “`netstat -s`” display summary statistics
- Shows
  - Information about each connection and various connection states
  - Information in regard to each protocol
  - Amount of incoming and outgoing packages
  - Various error states, for example TCP segments retransmitted!
- Hints
  - Inodes and program names are useful to reverse-map ports to applications
  - Option -s shows accumulated values since system start
  - There is always a low amount of packets in error or resets
  - Dropped segments show up on the sender side as retransmits
  - Use sadc/sar to identify the device

The “netstat” tool

- Example output “`netstat -s`”

```
Tcp:
    15813 active connections openings
    35547 passive connection openings
    305 failed connection attempts
    0 connection resets received
    6117 connections established
    81606342 segments received
    127803327 segments send out
    288729 segments retransmitted
    0 bad segments received.
```

The socket statistics “ss” tool

- Another utility to investigate sockets
- Usage: “`ss -aempi`”
- Shows
  - Socket options
  - Socket receive and send queues
  - Inode, socket identifiers
- Example output

```
ss -aempi
  State       Recv-Q Send-Q    Local Address:Port       Peer Address:Port
  LISTEN      0      128                   :::ssh                   :::*
      users:(("sshd",959,4)) ino:7851 sk:ef858000  mem:(r0,w0,f0,t0)
```

- Hints
  - Inode numbers can assist reading strace logs
  - Check long outstanding queue elements

The “iptraf” tool

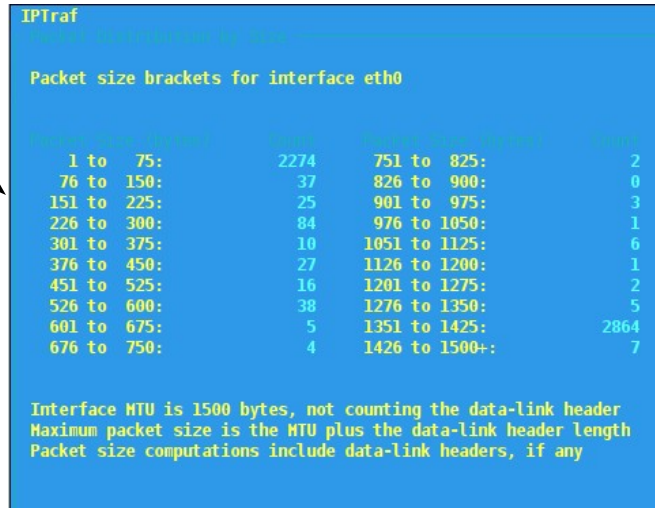
- Interactive colorful IP LAN monitor
- Usage: “`iptraf`”
- Shows
  - Live information on network devices / connections
  - Details per Connection / Interface
  - Statistical breakdown of ports / packet sizes
  - LAN station monitor

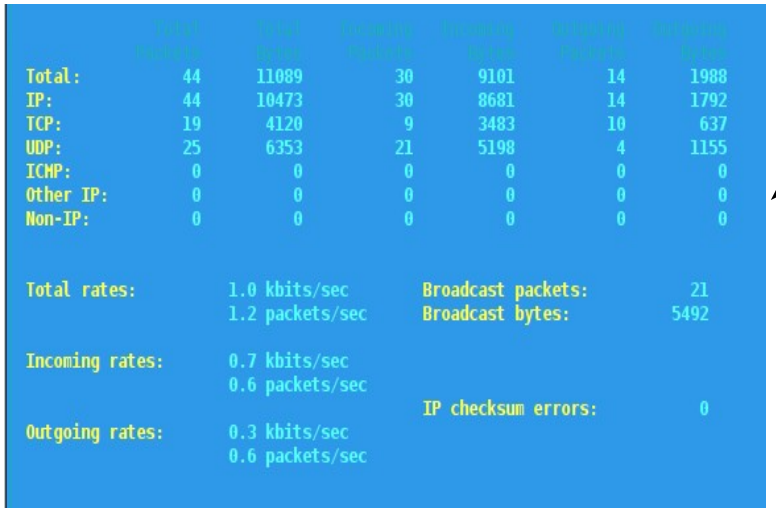
- Hints
  - Can be used for background logging as well
    - Use SIGUSR1 and logrotate to handle the growing amount of data
  - Knowledge of packet sizes important for the right tuning

The “iptraf” tool

- Questions that usually can be addressed
  - Connection behavior overview
  - Do you have peaks in your workload characteristic
  - Who does your host really communicate with
- Comparison to wireshark
  - Not as powerful, but much easier and faster to use
  - Lower overhead and no sniffing needed (often prohibited)

Packet sizes





IF details

The “tcpdump” tool

- analyze packets of applications manually
- Usage: “`tcpdump ...`”

```
tcpdump host pserver1
tcpdump: verbose output suppressed, use -v or -vv for full protocol decode
listening on eth0, link-type EN10MB (Ethernet), capture size 65535 bytes
13:30:00.326581 IP pserver1.boeblingen.de.ibm.com.38620 > p10lp35.boeblingen.de.ibm.com.ssh: Flags [.], ack 3142, win
102, options [nop,nop,TS val 972996696 ecr 346994], length 0

13:30:00.338239 IP p10lp35.boeblingen.de.ibm.com.ssh > pserver1.boeblingen.de.ibm.com.38620: Flags [P.], seq
3142:3222, ack 2262, win 2790, options [nop,nop,TS val 346996 ecr 972996696], length 80
13:30:00.375491 IP pserver1.boeblingen.de.ibm.com.38620 > p10lp35.boeblingen.de.ibm.com.ssh: Flags [.], ack 3222, win
102, options [nop,nop,TS val 972996709 ecr 346996], length 0
[...]
^C
31 packets captured
31 packets received by filter
0 packets dropped by kernel
```

- Not all devices support dumping packets in older distribution releases
  - Also often no promiscuous mode
- Check flags or even content if your expectations are met
- -w flag exports captured unparsed data to a file for later analysis
  - Also supported by wireshark
- Usually you have to know what you want to look for

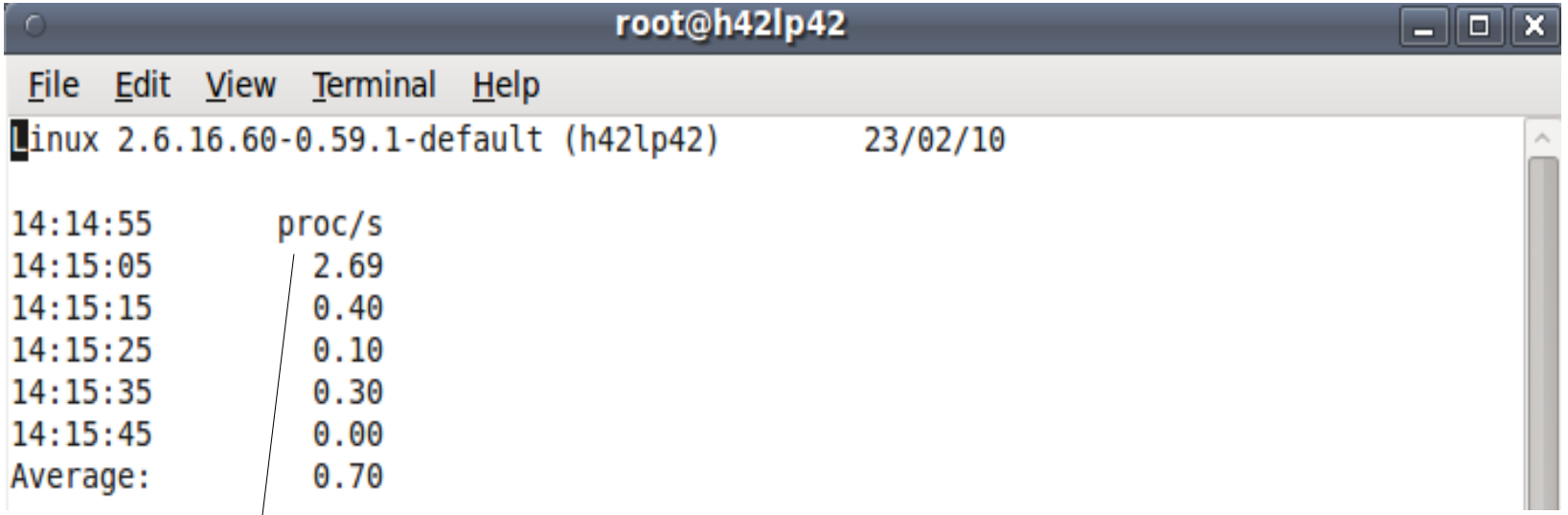
Monitoring

"For the hard problems"

The “SADC/SAR” tool

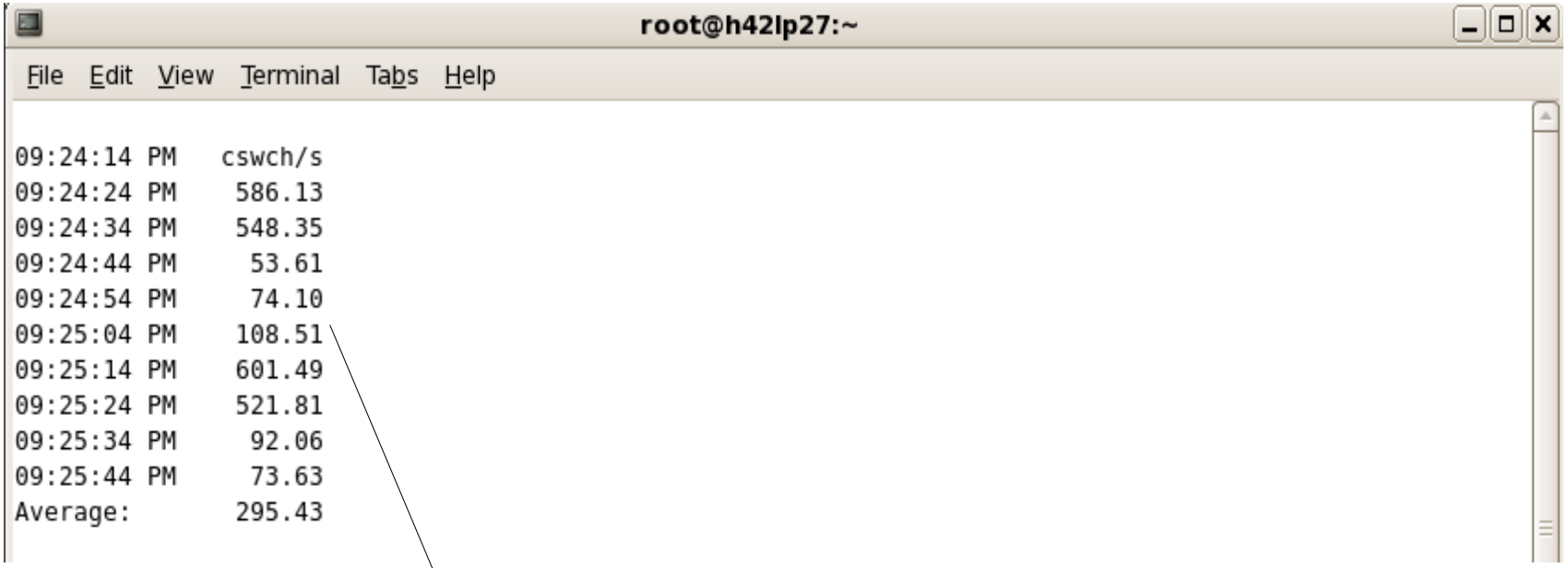
- System activity data collector and analysis
  - Suitable for permanent system monitoring and detailed analysis
- Usage: “`/usr/lib64/sa/sadc [-S XALL] [interval in sec] [outfile]`”
  “`sar -A -f [outfile]`”
- Shows
  - Reports statistics data over time and creates average values for each item
  - CPU and memory utilization
  - Disk I/O overview and on device level
  - Network I/O and errors on device level
  - … and much more
- Hints
  - Shared memory is listed under 'cache'
  - [outfile] is a binary file, which contains all values. It is formatted using sar
  - sadc parameter “-S XALL” enables the gathering of further optional data
    - enables the creation of item specific reports, e.g. network only
    - enables the specification of a start and end time → time of interest

The “SAR” output – processes created



Processes created per second usually small except during startup.
If constantly at a high rate your application likely has an issue.
Be aware – the numbers scale with your system size and setup.

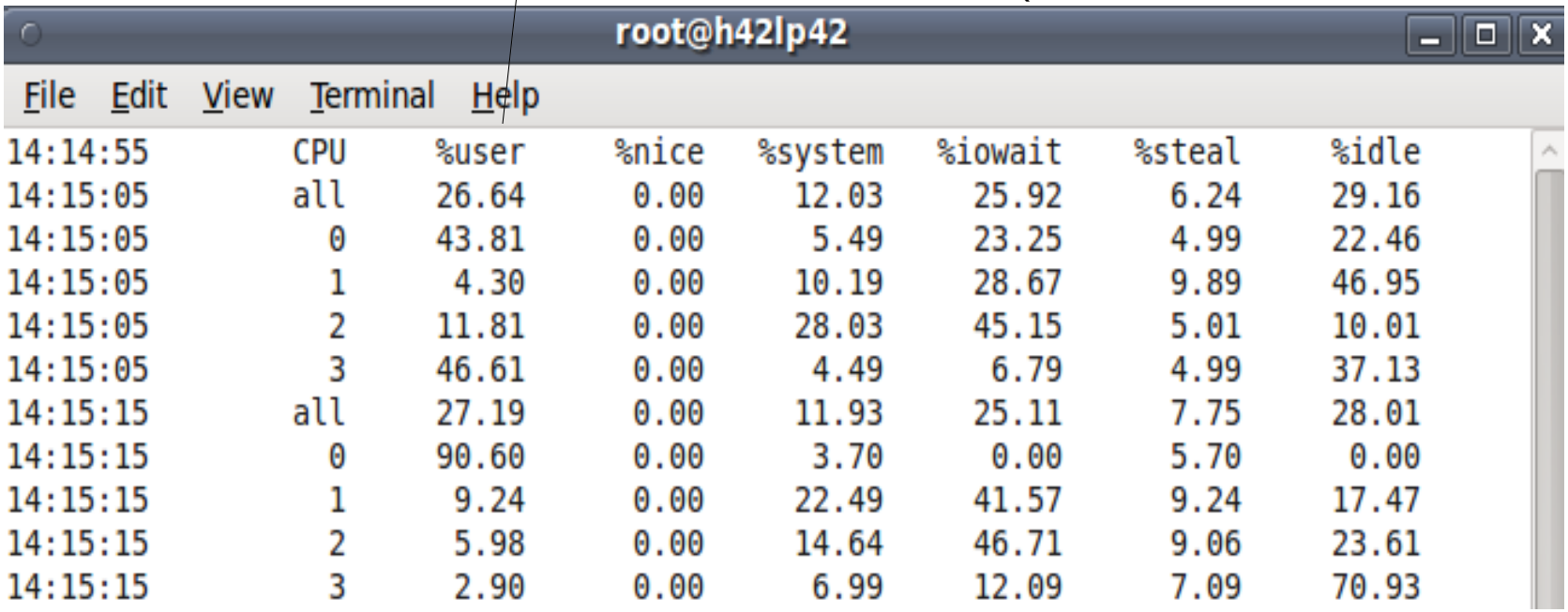
The “SAR” output – context switch rate



Context switches per second usually < 1000 per cpu except during startup or while running a benchmark if > 10000 your application might have an issue.

The “SAR” output – CPU utilization

Per CPU values:
watch out for
- system time (kernel)
- user (applications)
- irq/soft (kernel, interrupt handling)
- idle (nothing to do)
- iowait time (runnable but waiting for I/O)
- steal time (runnable but utilized somewhere else)



14:14:55	CPU	%user	%nice	%system	%iowait	%steal	%idle
14:15:05	all	26.64	0.00	12.03	25.92	6.24	29.16
14:15:05	0	43.81	0.00	5.49	23.25	4.99	22.46
14:15:05	1	4.30	0.00	10.19	28.67	9.89	46.95
14:15:05	2	11.81	0.00	28.03	45.15	5.01	10.01
14:15:05	3	46.61	0.00	4.49	6.79	4.99	37.13
14:15:15	all	27.19	0.00	11.93	25.11	7.75	28.01
14:15:15	0	90.60	0.00	3.70	0.00	5.70	0.00
14:15:15	1	9.24	0.00	22.49	41.57	9.24	17.47
14:15:15	2	5.98	0.00	14.64	46.71	9.06	23.61
14:15:15	3	2.90	0.00	6.99	12.09	7.09	70.93

The “SAR” output – network traffic

root@h42lp42

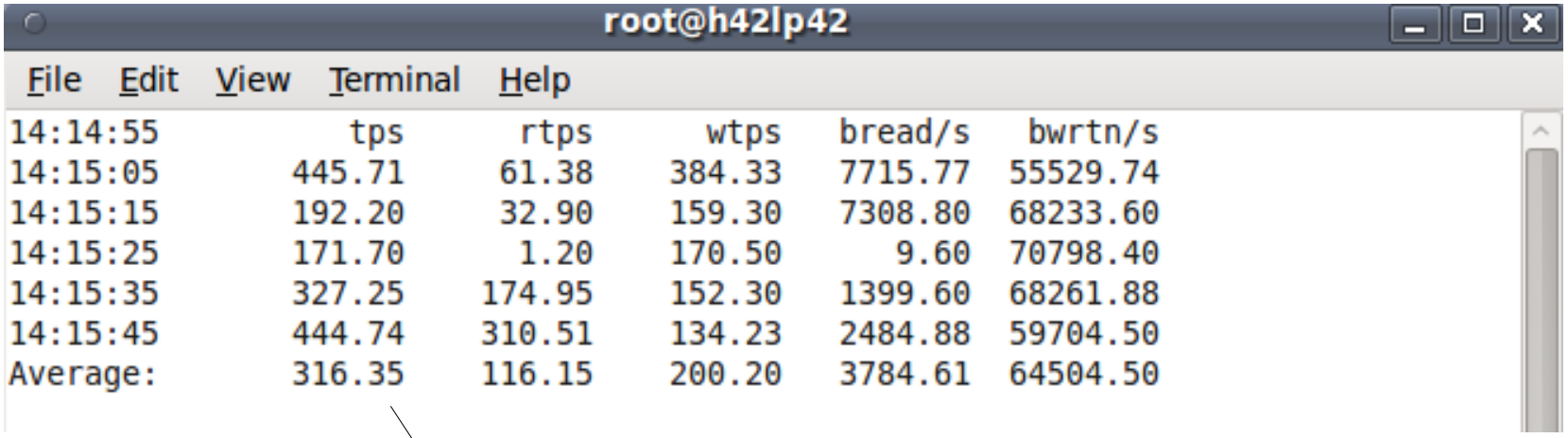
File Edit View Terminal Help

```
14:14:55        IFACE   rxpck/s   txpck/s    rxkB/s    txkB/s   rxcmp/s   txcmp/s  rxmcst/s
14:15:05           lo      0.00      0.00      0.00      0.00      0.00      0.00      0.00
14:15:05         sit0      0.00      0.00      0.00      0.00      0.00      0.00      0.00
14:15:05         eth0   4587.92   5278.34    307.53    482.56      0.00      0.00      0.00
14:15:15           lo      0.00      0.00      0.00      0.00      0.00      0.00      0.00
14:15:15         sit0      0.00      0.00      0.00      0.00      0.00      0.00      0.00
14:15:15         eth0   4206.40   4827.10    281.43    441.17      0.00      0.00      0.00
```

Per interface statistic of packets/bytes
You can easily derive average packet sizes from that.
Sometimes people expect - and planned for – different sizes.

Has another panel for errors, drops and such events.

The “SAR” output – disk I/O overall



Overview of
- operations per second
- transferred amount

The “SAR” output – disk I/O per device

root@h42lp42

File Edit View Terminal Help

14:18:14	DEV	tps	rd_sec/s	wr_sec/s	avgrq-sz	avgqu-sz	await	svctm	%util
14:18:24	dev94-0	7.41	260.26	37.64	40.22	0.01	1.35	0.95	0.70
14:18:24	dev94-4	403.20	46784.38	13756.96	150.15	5.06	12.56	2.03	81.88
14:18:24	dev94-8	547.15	22830.83	21249.25	80.56	3.42	6.25	1.39	76.18
14:18:34	dev94-0	8.30	557.31	10.28	68.38	0.01	1.31	0.71	0.59
14:18:34	dev94-4	284.39	35453.75	35618.18	249.91	7.82	23.45	2.97	84.58
14:18:34	dev94-8	549.51	16032.41	41554.94	104.80	25.23	40.35	1.42	78.06

Is your I/O balanced across devices?
Imbalances can indicate issues wit a LV setup.

tps and avgrq-sz combined can be important.
Do they match your sizing assumptions?

Await shows the time the application has to wait.

The “SAR” output – memory statistics

root@h42lp42

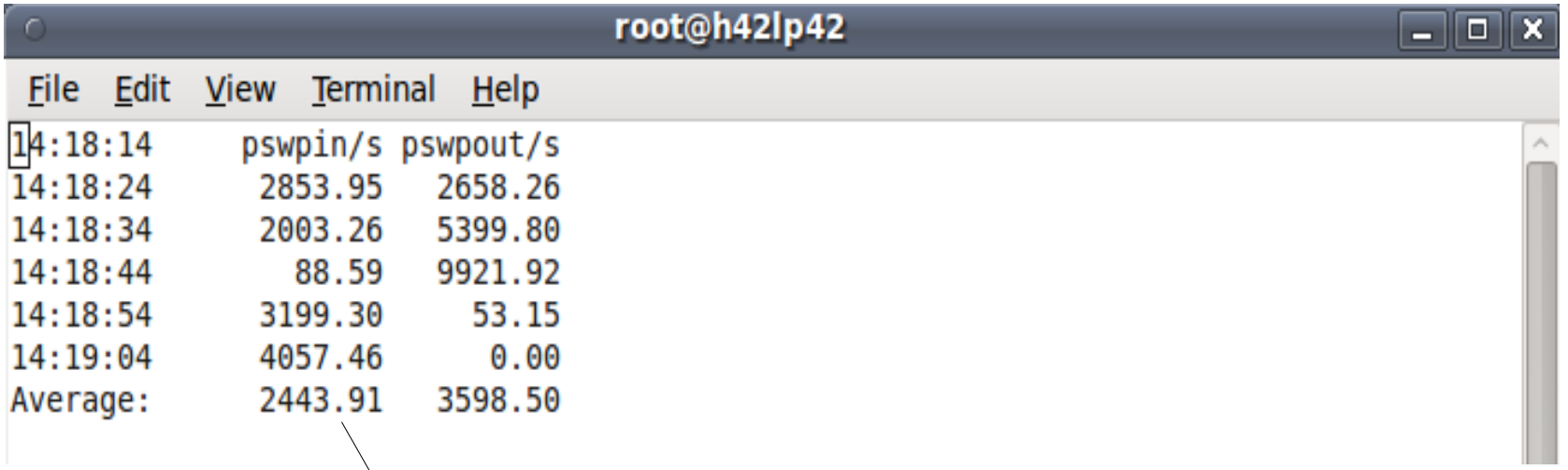
File Edit View Terminal Help

14:18:14	kbmemfree	kbmemused	%memused	kbbuffers	kbcached	kbswpfree	kbswpused	%swpused	kbswpcad
14:18:24	9616	2045284	99.53	2772	90328	1621184	782792	32.56	616916
14:18:34	8624	2046276	99.58	2936	154636	1443732	960244	39.94	729948
14:18:44	7024	2047876	99.66	5400	240140	1132356	1271620	52.90	953644
14:18:54	7308	2047592	99.64	4556	348796	1201988	1201988	50.00	778752
14:19:04	7876	2047024	99.62	7800	333844	1201988	1201988	50.00	780656
Average:	8090	2046810	99.61	4693	233549	1320250	1083726	45.08	771983

Be aware that high %memused and low kbmemfree
is no indication of a memory shortage (common mistake).

Same for swap – to use swap is actually good,
but to access it (swapin/-out) all the time is bad.

The “SAR” output – memory pressure / swap



The percentage seen before can be high,
But the swap rate shown here should be low.
Ideally it is near zero after a rampup time.
High rates can indicate memory shortages.

The “SAR” output – memory pressure faults and reclaim

h37lp19 : root

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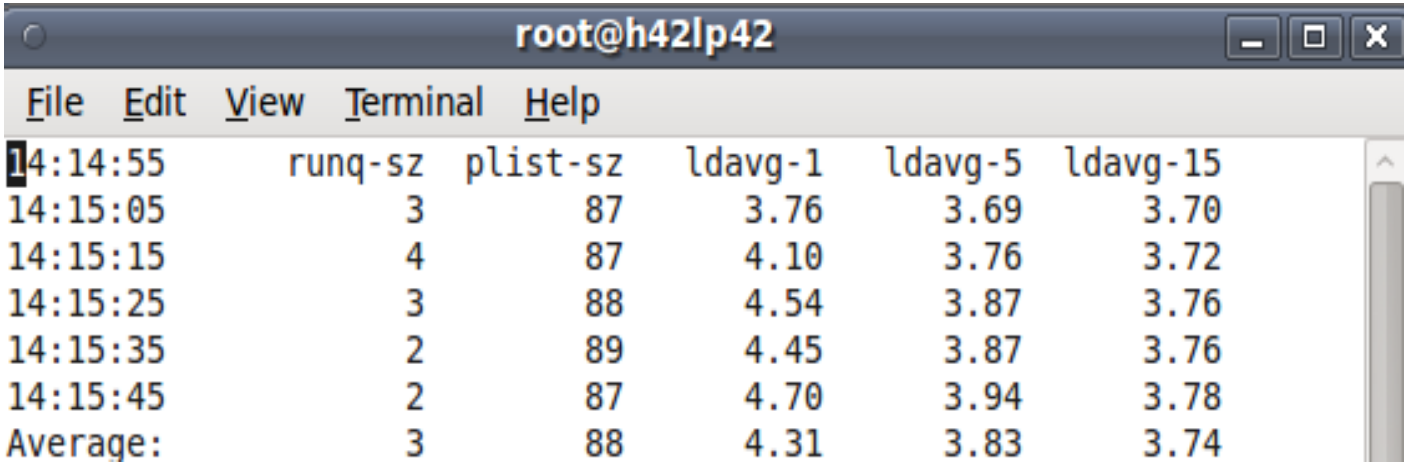
	pgpgin/s	pgpgout/s	fault/s	majflt/s	pgfree/s	pgscank/s	pgscand/s	pgsteal/s	%vmeff
10:12:15 AM									
10:12:17 AM	109.45	336.32	634.83	1.99	4710.95	0.00	0.00	0.00	0.00
10:12:19 AM	174.00	18.00	109.00	1.00	76.50	0.00	0.00	0.00	0.00
10:12:21 AM	0.00	18.00	36.00	0.00	71.00	0.00	0.00	0.00	0.00
10:12:23 AM	826.00	327910.00	1697.00	8.50	64659.00	66066.50	5424.50	64285.50	89.92
10:12:25 AM	577.11	715393.03	43.28	1.49	178377.61	110505.47	96352.24	178305.97	86.20
10:12:27 AM	588.12	679320.79	43.07	1.49	169312.87	101317.82	94495.54	169250.00	86.43
10:12:29 AM	1040.00	688822.00	62.00	2.50	171417.50	99329.50	100065.50	171355.50	85.94
10:12:31 AM	698.04	663082.35	45.59	2.45	165792.65	93984.80	95946.57	165715.69	87.25
10:12:33 AM	1212.12	624048.48	84.34	4.55	155524.75	90932.32	87934.85	155378.28	86.87
10:12:35 AM	595.07	215950.74	68.47	2.46	54027.09	27919.70	32992.61	53903.45	88.49
10:12:37 AM	558.00	159790.00	43.50	1.50	38183.00	18968.50	21232.00	38122.50	94.83
10:12:39 AM	1569.85	21949.75	102.51	4.02	5976.38	3144.72	2990.95	5868.84	95.65
10:12:41 AM	1081.55	527207.77	213.59	1.46	134243.20	65822.33	90253.40	134170.87	85.97
10:12:43 AM	1718.59	702936.68	62.31	2.51	176173.37	86268.34	118320.10	176107.54	86.08
10:12:45 AM	1237.44	683623.65	42.86	1.48	171228.57	83624.14	114011.33	171166.01	86.61
10:12:47 AM	1269.39	699144.90	44.39	1.53	173979.08	89181.63	112045.41	173909.69	86.42
10:12:49 AM	1691.54	677327.36	62.19	2.49	171114.93	89499.00	104974.13	171048.26	87.95
10:12:51 AM	1979.70	285857.87	143.15	4.57	69777.16	37740.61	44834.01	69590.86	84.28
10:12:53 AM	458.00	20.00	57.00	1.00	156.50	98.00	0.00	96.00	97.96
10:12:55 AM	433751.72	5944.83	1818.23	24.14	109168.97	3466.01	210573.89	108376.85	50.63
10:12:57 AM	924042.00	336.00	248.50	26.50	231500.50	2384.50	461443.00	231027.50	49.81
10:12:59 AM	906810.00	214.00	225.00	25.00	226950.50	2117.00	447010.00	226605.50	50.45
10:13:01 AM	917504.00	180.00	206.00	38.00	230020.50	2225.00	460268.00	229486.50	49.62
10:13:03 AM	865062.00	348.00	464.00	58.00	216892.50	7677.50	419680.50	215976.00	50.54
10:13:05 AM	12.06	20.10	42.21	0.00	267.84	160.80	16.08	176.88	100.00
10:13:07 AM	770.15	123.38	201.99	9.95	266.17	131.34	0.00	130.85	99.62
10:13:09 AM	484.42	20.10	64.32	2.51	263.82	192.96	0.00	192.96	100.00
10:13:11 AM	16.00	20.00	38.50	0.50	96.00	0.00	0.00	0.00	0.00
10:13:13 AM	0.00	20.00	36.00	0.00	95.50	0.00	0.00	0.00	0.00
10:13:15 AM	2700.00	318.00	698.00	9.00	22343.00	301.00	0.00	287.00	95.35
10:13:17 AM	2.00	20.00	36.00	0.00	60.50	0.00	0.00	0.00	0.00
10:13:19 AM	0.00	20.00	36.00	0.00	61.50	0.00	0.00	0.00	0.00
10:13:21 AM	5558.21	662674.63	2378.11	9.95	147166.17	77842.79	94354.23	146721.39	85.21
10:13:23 AM	1039.22	1052684.31	60.78	2.45	260784.31	116591.18	193280.39	260718.14	84.14

- Don't trust pgpgin/-out absolute values
- Faults populate memory
- Major faults need I/O
- Scank/s is background reclaim by kswap/flush (modern)
- Scand/s is reclaim with a “waiting” allocation
- Steal is the amount reclaimed by those scans

The “SAR” output – system load



Runqueue size are the currently runnable programs.
It's not bad to have many, but if they exceed the amount of CPUs you could do more work in parallel.

Plist-sz is the overall number of programs, if that is always growing you have likely a process starvation or connection issue.

Load average is a runqueue length average for 1/5/15 minutes.

The “dstat” tool

- Versatile tool for generating system resource statistics
- Usage: `dstat -tv –aio –disk-util -n –net-packets -i –ipc -D total,[diskname] –top-io [...] [interval]`
- Short: `dstat -vtin`
- Shows
  - Throughput
  - Utilization
  - Summarized and per device queue information
  - Much more, it more or less combines several classic tools like iostat and vmstat
- Hints
  - Powerful plug-in concept
    - “`--top-io`” for example identifies the application causing the most I/Os
  - Colorization allows fast identification of deviations

The “dstat” tool

```
Report nice bugs to bug-coreutils@gnu.org
GNU coreutils home page: <http://www.gnu.org/software/coreutils/>
General help using GNU software: <http://www.gnu.org/gethelp/>
For complete documentation, run: info coreutils 'nice invocation'
[root@r3729001 ~]# nice -n 1 dstat -tv --aio --disk-util -n --net-packets -i --ipc -D total,sda --top-io --noupdate 5
----system---- ---procs--- ------memory-usage----- ---paging-- -dsk/total----dsk/sda-- ---system-- ----total-cpu-usage---- async sda-
     time     |run blk new| used  buff  cach  free|  in   out | read  writ: read  writ| int   csw |usr sys idl wai hiq siq| #aio|util|
17-07 17:41:18|0.0   0  38|1303M 13.5M 10.4G 57.4M|   0     0 |4137k   14M: 124k  337k|   0  4968 |  4   3  92   0   0   1|    0 |1.59|
17-07 17:41:24| 13   0   0|1307M 13.5M 10.4G 57.2M|   0     0 |1708k   30k:  45k     0 |   0    16k| 33   9  55   0   0   3|    0 |0.20|
17-07 17:41:28|9.4 0.2   0|1311M 13.5M 10.4G 59.0M|   0     0 |1626k   19k:  60k     0 |   0    15k| 63  15  17   0   0   5|    0 |0.20|
17-07 17:41:34| 13   0 0.2|1313M 13.5M 10.4G 59.5M|   0     0 |1325k   11k:  32k     0 |   0    11k| 71  17   6   0   0   6|    0 |   0|
17-07 17:41:39|3.6   0   0|1317M 13.6M 10.4G 60.8M|   0     0 |1258k   23k:  26k     0 |   0    16k| 76  18   0   0   0   6|    0 |0.40|
17-07 17:41:44| 13   0   0|1318M 13.6M 10.4G 53.1M|   0     0 |1601k   16k:  37k     0 |   0    14k| 75  19   0   0   0   6|    0 |0.40|
17-07 17:41:49| 11   0 0.2|1322M 13.6M 10.4G 82.2M|   0     0 | 811k   16k:  31k     0 |   0    13k| 67  28   0   0   0   5|    0 |0.20|
17-07 17:41:53| 12 0.4   0|1324M 13.6M 10.4G 68.7M|   0     0 | 909k 3277B:  40k     0 |   0  9820 | 26   6  65   0   0   2|    0 |0.20|
```

similar to vmstat

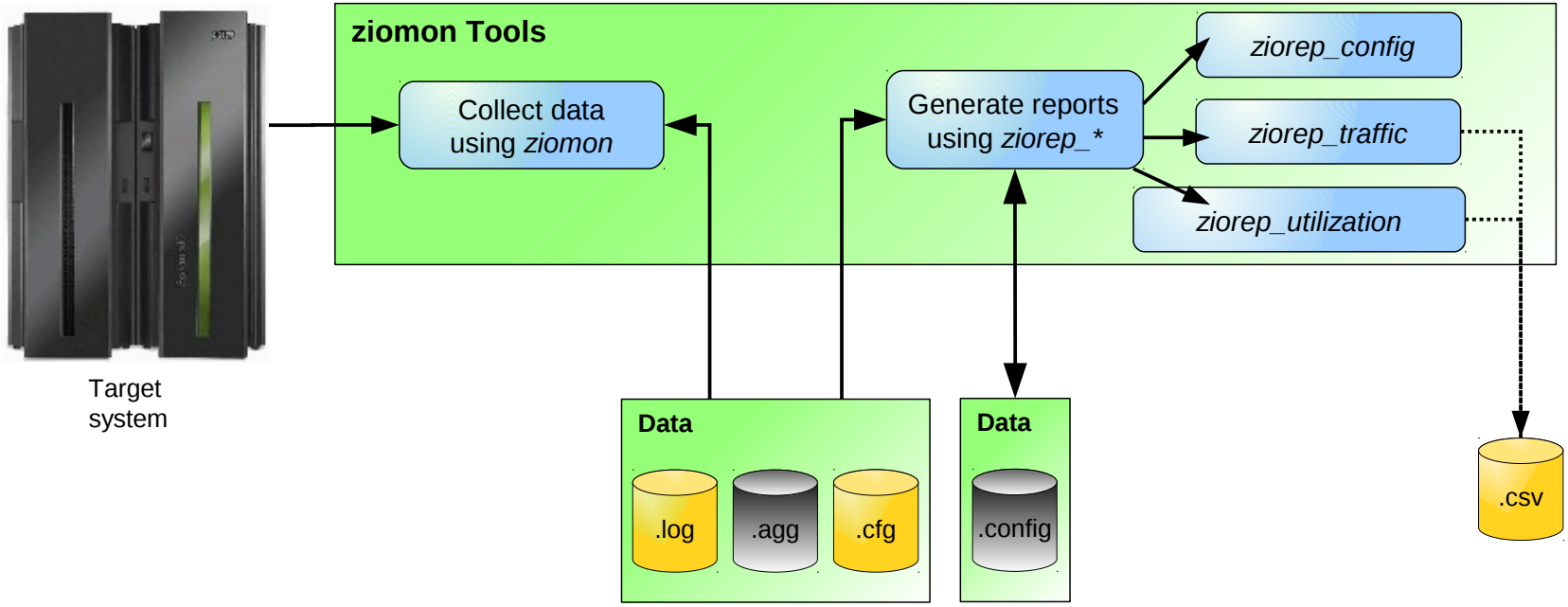
similar to iostat (also per device)

new in live tool

```
kets -i --ipc -D total,sda --top-io --noupdate 5
otal----dsk/sda-- ---system-- ----total-cpu-usage---- async sda- -net/total- -pkt/total- inter --sysv-ipc- ----most-expensive----
writ: read  writ| int   csw |usr sys idl wai hiq siq| #aio|util| recv  send|#recv #send|  1   |msg sem shm|     i/o process
 14M: 124k  337k|   0  4968 |  4   3  92   0   0   1|    0 |1.59|   0     0 |   0     0 | 300  |   0  35   1|sshd          15M   25M
 30k:  45k     0 |   0    16k| 33   9  55   0   0   3|    0 |0.20|  21B  426B|0.40  0.40 |  81  |   0  35   1|postgres: p  78k     0
 19k:  60k     0 |   0    15k| 63  15  17   0   0   5|    0 |0.20|  10B  148B|0.20  0.20 |  74  |   0  35   1|postgres: p  75k     0
 11k:  32k     0 |   0    11k| 71  17   6   0   0   6|    0 |   0|142B  148B|0.60  0.20 |  62  |   0  35   1|postgres: p 141k     0
 23k:  26k     0 |   0    16k| 76  18   0   0   0   6|    0 |0.40|133B  151B|0.60  0.20 |  75  |   0  35   1|postgres: p  32k     0
 16k:  37k     0 |   0    14k| 75  19   0   0   0   6|    0 |0.40|  10B  151B|0.20  0.20 |  73  |   0  35   1|postgres: p 152k     0
 16k:  31k     0 |   0    13k| 67  28   0   0   0   5|    0 |0.20|162B  161B|0.80  0.40 |  53  |   0  35   1|postgres: p  22k     0
277B:  40k     0 |   0  9820 | 26   6  65   0   0   2|    0 |0.20|  10B  151B|0.20  0.20 |  41  |   0  35   1|postgres: p 110k     0
```

The ziomon

- Analyze your FCP based I/O
- Usage: "`ziomon`" → "`ziorep*`"



- Be aware that ziomon can be memory greedy if you have very memory constrained systems
- The has many extra functions please check out the live virtual class of Stephan Raspl
  - PDF: http://www.vm.ibm.com/education/lvc/LVC0425.pdf
  - Replay: http://ibmstg.adobeconnect.com/p7zvdjz0yye/

Questions

- Further information is available at
  - Linux on System z – Tuning hints and tips
    http://www.ibm.com/developerworks/linux/linux390/perf/index.html
  - Live Virtual Classes for z/VM and Linux
    http://www.vm.ibm.com/education/lvc/

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Linux on System z
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