性能分析工具的学习与使用

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1. Graph500 的使用

在官网下载graph500之后，直接make即可编译出graph500_reference_bfs和graph500_reference_bfs_sssp，直接使用这两个程序即可。

根据官网提供的数据,如下图所示

PROBLEM CLASS	SCALE	EDGE FACTOR
Toy (level 10)	26	16
Mini (level 11)	29	16
Small (level 12)	32	16
Medium (level 13)	36	16
Large (level 14)	39	16
Huge (level 15)	42	16

结合机器性能，参数设定为 SCALE <= 26，EDGE FACTOR = 16 较为合理。

2. strace

strace 可以查看程序的系统调用，直接在程序调用前使用即可。

```
strace graph500_reference_bfs 16 16
```

```
zyh@pc:~/Desktop/计算机系统性能测试/graph500-graph500-3.0.0/src$ strace ./graph500_reference_bfs 2 2
execve("./graph500_reference_bfs", ["./graph500_reference_bfs", "2", "2"], 0x7ffebf175130 /* 91 vars */) = 0
brk(NULL)                               = 0x561bf827b000
access("/etc/ld.so.nohwcap", F_OK)      = -1 ENOENT (No such file or directory)
access("/etc/ld.so.preload", R_OK)      = -1 ENOENT (No such file or directory)
openat(AT_FDCWD, "/home/zyh/catkin_ws/devel/lib/tls/haswell/x86_64/libm.so.6", O_RDONLY|O_CLOEXEC) = -1 ENOE
NT (No such file or directory)
stat("/home/zyh/catkin_ws/devel/lib/tls/haswell/x86_64", 0x7ffdd8a17480) = -1 ENOENT (No such file or direct
ory)
openat(AT_FDCWD, "/home/zyh/catkin_ws/devel/lib/tls/haswell/libm.so.6", O_RDONLY|O_CLOEXEC) = -1 ENOENT (No
such file or directory)
stat("/home/zyh/catkin_ws/devel/lib/tls/haswell", 0x7ffdd8a17480) = -1 ENOENT (No such file or directory)
openat(AT_FDCWD, "/home/zyh/catkin_ws/devel/lib/tls/x86_64/libm.so.6", O_RDONLY|O_CLOEXEC) = -1 ENOENT (No s
uch file or directory)
stat("/home/zyh/catkin_ws/devel/lib/tls/x86_64", 0x7ffdd8a17480) = -1 ENOENT (No such file or directory)
openat(AT_FDCWD, "/home/zyh/catkin_ws/devel/lib/tls/libm.so.6", O_RDONLY|O_CLOEXEC) = -1 ENOENT (No such fil
e or directory)
stat("/home/zyh/catkin_ws/devel/lib/tls", 0x7ffdd8a17480) = -1 ENOENT (No such file or directory)
openat(AT_FDCWD, "/home/zyh/catkin_ws/devel/lib/haswell/x86_64/libm.so.6", O_RDONLY|O_CLOEXEC) = -1 ENOENT (
No such file or directory)
stat("/home/zyh/catkin_ws/devel/lib/haswell/x86_64", 0x7ffdd8a17480) = -1 ENOENT (No such file or directory)
openat(AT_FDCWD, "/home/zyh/catkin_ws/devel/lib/haswell/libm.so.6", O_RDONLY|O_CLOEXEC) = -1 ENOENT (No such
 file or directory)
stat("/home/zyh/catkin_ws/devel/lib/haswell", 0x7ffdd8a17480) = -1 ENOENT (No such file or directory)
openat(AT_FDCWD, "/home/zyh/catkin_ws/devel/lib/x86_64/libm.so.6", O_RDONLY|O_CLOEXEC) = -1 ENOENT (No such
file or directory)
stat("/home/zyh/catkin_ws/devel/lib/x86_64", 0x7ffdd8a17480) = -1 ENOENT (No such file or directory)
openat(AT_FDCWD, "/home/zyh/catkin_ws/devel/lib/libm.so.6", O_RDONLY|O_CLOEXEC) = -1 ENOENT (No such file or
 directory)
```

可以看到系统调用的函数名，调用参数和返回值，如果有错误还可以看到简单的错误信息。

3. perf

Ubuntu下需要根据内核版本安装

```
sudo apt install linux-tools-5.3.0-40-generic
```

perf的功能十分强大，不过有些指令需要相应内核和权限

perf top 可以实时显示性能统计信息

```
Samples: 155K of event 'cycles', 4000 Hz, Event count (approx.): 59177199860 lost: 0/0 drop: 0/0
Overhead  Shared Object                     Symbol
  22.41%  graph500_reference_bfs            [.] edgepreddisthndl
  17.02%  graph500_reference_bfs            [.] aml_send
  10.01%  graph500_reference_bfs            [.] frompredhndl
   7.90%  graph500_reference_bfs            [.] validate_result
   6.97%  graph500_reference_bfs            [.] run_bfs
   5.22%  graph500_reference_bfs            [.] get_edge_count_for_teps
   4.58%  graph500_reference_bfs            [.] makedepthmapforbfs
   3.36%  graph500_reference_bfs            [.] mrg_get_uint_orig
   2.62%  graph500_reference_bfs            [.] generate_kronecker_range
   2.17%  graph500_reference_bfs            [.] visithndl
   1.79%  graph500_reference_bfs            [.] mrg_apply_transition
   1.50%  graph500_reference_bfs            [.] fulledgehndl
   0.69%  [kernel]                          [k] do_syscall_64
   0.49%  graph500_reference_bfs            [.] convert_graph_to_oned_csr
   0.39%  graph500_reference_bfs            [.] aml_my_pe
   0.35%  [kernel]                          [k] entry_SYSCALL_64
   0.29%  libc-2.27.so                      [.] __GI___strcmp_ssse3
   0.27%  [kernel]                          [k] syscall_return_via_sysret
   0.12%  libglib-2.0.so.0.5600.4           [.] g_hash_table_lookup
   0.12%  graph500_reference_bfs            [.] mrg_skip
   0.11%  libc-2.27.so                      [.] cfree@GLIBC_2.2.5
For a higher level overview, try: perf top --sort comm,dso
```

perf stat 分析程序整体性能

```
perf stat ./graph500_reference_bfs 20 16
```

```
Performance counter stats for './graph500_reference_bfs 20 16':

       122,917.99 msec task-clock                #    0.999 CPUs utilized
            1,407      context-switches          #    0.011 K/sec
               11      cpu-migrations            #    0.000 K/sec
          111,450      page-faults               #    0.907 K/sec
  473,799,027,704      cycles                    #    3.855 GHz
  652,938,468,274      instructions              #    1.38  insn per cycle
   83,870,282,373      branches                  #  682.327 M/sec
    1,795,333,131      branch-misses             #    2.14% of all branches

    123.036032067 seconds time elapsed

    122.740891000 seconds user
      0.143977000 seconds sys
```

4. vmstat

vmstat 可以展现给定时间间隔的状态值,包括CPU使用率，内存使用，虚拟内存交换情况,IO读写情况。

通过两个数字参数来完成的，第一个参数是采样的时间间隔数，单位是秒，第二个参数是采样的次数。

```
zyh@pc:~$ vmstat 1 100
procs -----------memory---------- ---swap-- -----io---- -system-- ------cpu-----
 r  b   swpd   free   buff  cache   si   so    bi    bo   in   cs us sy id wa st
 1  0      0 9407964 407416 3017400    0    0   128    49  343 1081  8  3 89  0  0
 1  0      0 9412508 407424 3017400    0    0     0   100  793 2046 26  1 73  0  0
 1  0      0 9412500 407424 3017396    0    0     0     0 1468 3694 25  2 72  0  0
 1  0      0 9412500 407424 3017396    0    0     0     0  744 1818 26  1 73  0  0
 1  0      0 9412500 407424 3017396    0    0     0     0  717 1511 26  1 73  0  0
 1  0      0 9412200 407424 3017396    0    0     0     0 1509 5458 27  5 69  0  0
 0  0      0 9850364 407432 3009352    0    0     0    52 1321 3093 25  2 73  0  0
 0  0      0 9850840 407432 3009036    0    0     0     0  578 1988  4  1 96  0  0
 1  0      0 9850840 407432 3009036    0    0     0     0  423 1671  2  1 98  0  0
 1  0      0 9850840 407432 3009036    0    0     0     0  476 1933  2  0 98  0  0
 1  0      0 9851092 407432 3009036    0    0     0     0 1061 2972  3  1 96  0  0
 0  0      0 9851092 407432 3009036    0    0     0     0  396 1671  2  1 97  0  0
 0  0      0 9851288 407444 3009036    0    0     0    68  554 1981  4  1 95  0  0
 0  0      0 9851336 407532 3009036    0    0     0   584  511 1780  2  1 97  1  0
 0  0      0 9851752 407532 3009228    0    0   228     0 1831 4474  5  2 93  0  0
 0  0      0 9851752 407532 3009228    0    0     0     0  481 2142  3  1 96  0  0
 0  0      0 9851752 407532 3009228    0    0     0     0  581 2206  3  1 96  0  0
 0  0      0 9851752 407532 3009228    0    0     0     0  420 1731  2  1 97  0  0
```

5. dstat

dstat也是一个性能统计工具，可以通过参数制定显示内容。

```
zyh@pc:~$ dstat -acnm
Terminal width too small, trimming output.
--total-cpu-usage-- -dsk/total- -net/total- ---paging-- ---system-- --total-cpu-usage-->
usr sys idl wai stl| read  writ| recv  send|  in   out | int   csw |usr sys idl wai stl>
  9   2  89   0   0| 471k  193k|   0     0 |   0     0 |1336  4224 |  9   2  89   0   0>
  2   0  98   0   0|   0    24k|4842B    0 |   0     0 | 267   751 |  2   0  98   0   0>
  2   1  97   0   0|   0     0 |  11k    0 |   0     0 |1076  4134 |  2   1  97   0   0>
  3   1  96   0   0|   0     0 |2375B    0 |   0     0 | 391  1510 |  3   1  96   0   0>
 15   1  84   0   0|   0   232k| 350B    0 |   0     0 |1729  3279 | 15   1  84   0   0>
 26   0  74   0   0|   0     0 |  12k  106B|   0     0 | 536   580 | 26   0  74   0   0>
 26   0  74   0   0|   0     0 |2754B    0 |   0     0 | 506   737 | 26   0  74   0   0>
 26   0  75   0   0|   0     0 |2262B    0 |   0     0 | 486   540 | 26   0  74   0   0>
 26   0  74   0   0|   0     0 |8652B    0 |   0     0 |1049  1591 | 26   0  74   0   0>
 26   1  74   0   0|   0    96k|4428B    0 |   0     0 | 507   559 | 26   1  74   0   0>
 27   1  72   0   0|   0     0 |2754B    0 |   0     0 |1240  4039 | 27   1  72   0   0>
 32   0  68   0   0|   0     0 |  10k  106B|   0     0 |1905  5751 | 32   0  68   0   0>
 32   2  67   0   0|   0    20k| 660B    0 |   0     0 |1931  5848 | 32   2  67   0   0>
 33   1  66   0   0|   0     0 |3974B    0 |   0     0 |1419  4271 | 33   1  66   0   0>
 29   0  70   0   0|   0     0 |  13k  125B|   0     0 |1523  4721 | 29   0  70   0   0>
 35   1  64   0   0|   0   188k|1525B  304B|   0     0 |1925  6938 | 35   1  64   0   0>
 30   2  68   0   0|   0     0 |1742B    0 |   0     0 |2018  5300 | 30   2  68   0   0>
```

6. free

free命令可以显示当前系统未使用的和已使用的内存数目，还可以显示被内核使用的内存缓冲区。

```
zyh@pc:~$ free -m
              total        used        free      shared  buff/cache   available
Mem:          15874        3335        9304         471        3234       11773
Swap:          2047           0        2047
```

可以看到开启程序后内存占用为3.3G。

7. iostat

iostat可以显示CPU和I/O系统的负载情况及分区状态信息。

```
zyh@pc:~$ iostat
Linux 5.3.0-40-generic (pc)     2020年03月03日  _x86_64_        (4 CPU)

avg-cpu:  %user   %nice %system %iowait  %steal   %idle
           7.59    0.08    2.31    0.04    0.00   89.99

Device             tps    kB_read/s    kB_wrtn/s    kB_read    kB_wrtn
loop0             5.84         5.94         0.00      57025          0
loop1             0.01         0.12         0.00       1114          0
loop2             0.00         0.03         0.00        328          0
loop3             0.05         0.08         0.00        787          0
loop4             0.00         0.01         0.00        116          0
loop5             0.00         0.01         0.00        116          0
loop6             0.00         0.03         0.00        330          0
loop7             0.05         0.08         0.00        800          0
sda               0.01         0.44         0.00       4204          0
sdb               0.01         0.44         0.00       4246          0
sdc              14.53       338.87       161.41    3250466    1548224
loop8             1.34         1.44         0.00      13799          0
loop9             0.01         0.12         0.00       1139          0
```

8. mpstat

mpstat用于获取 CPU 相关统计信息.

```
zyh@pc:~$ mpstat -P ALL 5 2
Linux 5.3.0-40-generic (pc)     2020年03月03日  _x86_64_        (4 CPU)

22时37分57秒  CPU    %usr   %nice    %sys %iowait    %irq   %soft  %steal  %guest  %gnice   %idle
22时38分02秒  all   27.66    0.00    1.26    0.05    0.00    4.02    0.00    0.00    0.00   67.01
22时38分02秒    0  100.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00
22时38分02秒    1    4.05    0.00    1.10    0.00    0.00    9.21    0.00    0.00    0.00   85.64
22时38分02秒    2    3.91    0.00    2.35    0.00    0.00    3.72    0.00    0.00    0.00   90.02
22时38分02秒    3    5.49    0.00    1.57    0.00    0.00    2.94    0.00    0.00    0.00   90.00

22时38分02秒  CPU    %usr   %nice    %sys %iowait    %irq   %soft  %steal  %guest  %gnice   %idle
22时38分07秒  all   28.97    0.00    1.67    0.00    0.00    2.55    0.00    0.00    0.00   66.81
22时38分07秒    0  100.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00
22时38分07秒    1    6.50    0.00    2.29    0.00    0.00    4.40    0.00    0.00    0.00   86.81
22时38分07秒    2    5.04    0.00    1.94    0.00    0.00    4.46    0.00    0.00    0.00   88.57
22时38分07秒    3    6.20    0.00    2.40    0.00    0.00    1.20    0.00    0.00    0.00   90.20

Average:      CPU    %usr   %nice    %sys %iowait    %irq   %soft  %steal  %guest  %gnice   %idle
Average:      all   28.31    0.00    1.46    0.02    0.00    3.29    0.00    0.00    0.00   66.91
Average:        0  100.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00
Average:        1    5.25    0.00    1.69    0.00    0.00    6.85    0.00    0.00    0.00   86.21
Average:        2    4.48    0.00    2.14    0.00    0.00    4.09    0.00    0.00    0.00   89.29
Average:        3    5.84    0.00    1.98    0.00    0.00    2.08    0.00    0.00    0.00   90.10
```

9. nicstat

nicstat可以统计网络流量

```
zyh@pc:~$ nicstat
    Time      Int   rKB/s   wKB/s   rPk/s   wPk/s    rAvs    wAvs %Util     Sat
22:44:06       lo    0.02    0.02    0.23    0.23   105.1   105.1  0.00    0.00
22:44:06 wlxe84e065697a3   10.92    0.55   21.43    3.99   521.7   141.0  0.00    0.00
```