ФЕДЕРАЛЬНОЕ ГОСУДАРСТВЕННОЕ АВТОНОМНОЕ ОБРАЗОВАТЕЛЬНОЕ УЧРЕЖДЕНИЕ ВЫСШЕГО ОБРАЗОВАНИЯ
“Научно-образовательная корпорация ИТМО”

ФАКУЛЬТЕТ ПРОГРАММНОЙ ИНЖЕНЕРИИ И КОМПЬЮТЕРНОЙ ТЕХНИКИ

Лабораторная работа №1

по дисциплине “Операционные системы”

Вариант:
Linux | vfork | bin-search | io-lat-read

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Задание

Часть 1. Запуск программ

Необходимо реализовать собственную оболочку командной строки - shell. Выбор ОС для реализации производится на усмотрение студента. Shell должен предоставлять пользователю возможность запускать программы на компьютере с переданными аргументами командной строки и после завершения программы показывать реальное время ее работы (подсчитать самостоятельно как «время завершения» – «время запуска»).

Часть 2. Мониторинг и профилирование

Разработать комплекс программ-нагрузчиков по варианту, заданному преподавателем. Каждый нагрузчик должен, как минимум, принимать параметр, который определяет количество повторений для алгоритма, указанного в задании. Программы должны нагружать вычислительную систему, дисковую подсистему или обе подсистемы сразу. Необходимо скомпилировать их без опций оптимизации компилятора.

Перед запуском нагрузчика, попробуйте оценить время работы вашей программы или ее результаты (если по варианту вам досталось измерение чего либо). Постарайтесь обосновать свои предположения. Предположение можно сделать, основываясь на свой опыт, знания ОС и характеристики используемого аппаратного обеспечения.

1. Запустите программу-нагрузчик и зафиксируйте метрики ее работы с помощью инструментов для профилирования. Сравните полученные результаты с ожидаемыми. Постарайтесь найти объяснение наблюдаемому.
2. Определите количество нагрузчиков, которое эффективно нагружает все ядра процессора на вашей системе. Как распределяются времена USER%, SYS%, WAIT%, а также реальное время выполнения нагрузчика, какое количество переключений контекста (вынужденных и невынужденных) происходит при этом?
3. Увеличьте количество нагрузчиков вдвое, втрое, вчетверо. Как изменились времена, указанные на предыдущем шаге? Как ведет себя ваша система?
4. Объедините программы-нагрузчики в одну, реализованную при помощи потоков выполнения, чтобы один нагрузчик эффективно нагружал все ядра вашей системы. Как изменились времена для того же объема вычислений? Запустите одну, две, три таких программы.

5. Добавьте опции агрессивной оптимизации для компилятора. Как изменились времена? На сколько сократилось реальное время исполнения программы нагрузчика?

Исходный код

https://github.com/dzschnd/os-lab-1

Предположения о свойствах программ-нагрузчиков

Алгоритм bin-search по моему варианту более вычислительно-ориентированный, соответственно будет более интенсивно использовать CPU и скорее всего выполнение займет значительно большее время, причем основную долю будут занимать пользовательские процессы. При этом алгоритм io-lat-read, зависящий от операций ввода/вывода, будет тратить больше времени на системные процессы. Работа комбинированного нагрузчика вероятно также, как и bin-search, будет состоять из пользовательских процессов, а от его оптимизированной версии ожидается значительно меньшее время выполнения и большая доля системных процессов.

Результаты измерений и метрик программ-нагрузчиков

Для анализа использовал команды perf, top, ltrace и strace, а также построил flame graph'ы при запуске четырех нагрузчиков: bin-search, io-lat-read, комбинированный через потоки выполнения алгоритм и последний, скомпилированный с опциями агрессивной компиляции. При этом использовались базовые значения итераций для алгоритмов и увеличенные в 2, 3 и 4 раза.

bin-search

25000000 итераций

logs > single > binSearch > ltrace.log

```
% time     seconds  usecs/call     calls      function
------ ----------- ----------- --------- --------------------
 78.48    0.000766         766         1 _ZdlPvm
 11.89    0.000116         116         1 _Znwm
  9.63    0.000094          94         1 atoi
------ ----------- ----------- --------- --------------------
100.00    0.000976                     3 total
```

logs > single > binSearch > strace.log

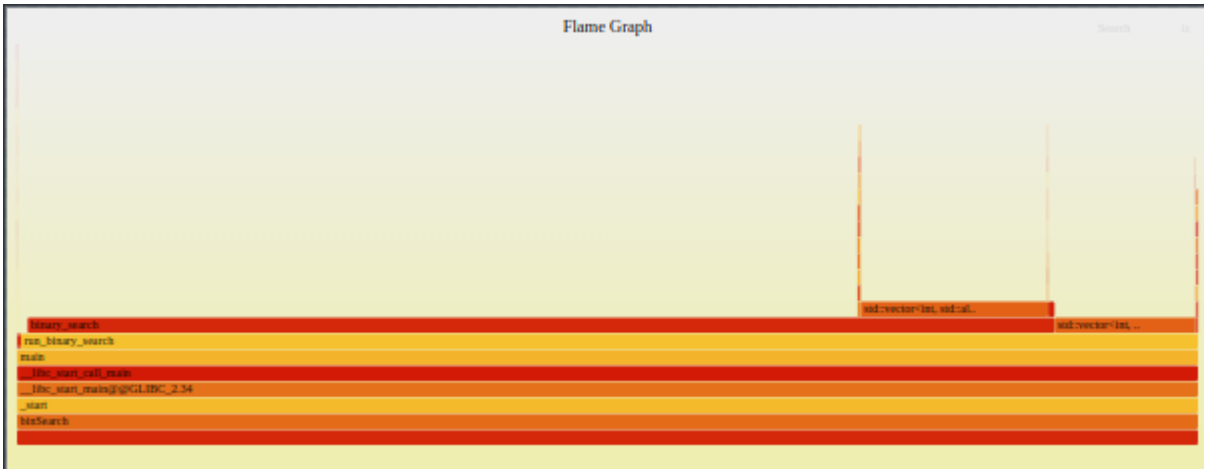
```
% time     seconds  usecs/call     calls    errors syscall
------ ----------- ----------- --------- --------- ----------------
 41.83    0.000284         284         1           execve
 29.90    0.000203           8        23           mmap
  7.81    0.000053           8         6           mprotect
  6.33    0.000043           8         5           openat
  2.95    0.000020           4         5           fstat
  2.50    0.000017           5         3           brk
  2.21    0.000015           3         4           read
  2.21    0.000015           3         5           close
  1.03    0.000007           3         2           pread64
  0.74    0.000005           5         1         1 access
  0.59    0.000004           4         1           getrandom
  0.44    0.000003           3         1           arch_prctl
  0.44    0.000003           3         1           set_tid_address
  0.44    0.000003           3         1           set_robust_list
  0.44    0.000003           3         1           rseq
  0.15    0.000001           0         2           munmap
  0.00    0.000000           0         1           futex
  0.00    0.000000           0         1           prlimit64
------ ----------- ----------- --------- --------- ----------------
100.00    0.000679          10        64         1 total
```

logs > single > binSearch > perf.log

```
Performance counter stats for './../exec/binSearch 25000000':

          1,942.80 msec task-clock                       #    0.999 CPUs utilized
                95      context-switches                 #   48.899 /sec
                 0      cpu-migrations                   #    0.000 /sec
             1,100      page-faults                      #  566.195 /sec
     7,430,986,304      cycles                           #    3.825 GHz                         (42.61%)
        37,928,510      stalled-cycles-frontend          #    0.51% frontend cycles idle        (42.71%)
    29,793,336,220      instructions                     #    4.01  insn per cycle
                                                  #    0.00  stalled cycles per insn     (42.81%)
     3,430,450,799      branches                         #    1.766 G/sec                       (42.86%)
         1,113,777      branch-misses                    #    0.03% of all branches             (42.92%)
     9,812,529,423      L1-dcache-loads                  #    5.051 G/sec                       (42.97%)
           941,553      L1-dcache-load-misses            #    0.01% of all L1-dcache accesses   (43.00%)
   <not supported>      LLC-loads
   <not supported>      LLC-load-misses
        18,341,891      L1-icache-loads                  #    9.441 M/sec                       (42.99%)
            20,603      L1-icache-load-misses            #    0.11% of all L1-icache accesses   (42.99%)
            26,698      dTLB-loads                       #   13.742 K/sec                       (42.94%)
             2,389      dTLB-load-misses                 #    8.95% of all dTLB cache accesses  (42.89%)
               112      iTLB-loads                       #   57.649 /sec                        (42.84%)
             4,462      iTLB-load-misses                 # 3983.93% of all iTLB cache accesses  (42.78%)
           157,785      L1-dcache-prefetches             #   81.215 K/sec                       (42.68%)
   <not supported>      L1-dcache-prefetch-misses

       1.945210683 seconds time elapsed

       1.936081000 seconds user
       0.007003000 seconds sys
```

logs > single > binSearch > top.log

```
top - 07:13:07 up 2 days, 19:24,  1 user,  load average: 3.32, 2.76, 2.18
Tasks: 474 total,  19 running, 399 sleeping,  56 stopped,   0 zombie
%Cpu(s): 94.3 us,  5.2 sy,  0.5 ni,  0.0 id,  0.0 wa,  0.0 hi,  0.0 si,  0.0 st
MiB Mem :  15808.0 total,   1081.0 free,   5295.2 used,   9910.9 buff/cache
MiB Swap:   4096.0 total,   4094.2 free,      1.8 used.  10512.8 avail Mem

    PID USER      PR  NI    VIRT    RES    SHR S  %CPU  %MEM     TIME+ COMMAND
 413834 root      20   0   10264   6784   2688 R 100.0   0.0   0:00.25 binSear+
 413835 root      20   0   10264   6912   2816 R 100.0   0.0   0:00.24 binSear+
 413837 root      20   0   10264   6912   2816 R 100.0   0.0   0:00.25 binSear+
 413839 root      20   0   10264   7040   2944 R 100.0   0.0   0:00.25 binSear+
 413841 root      20   0   10264   7040   2944 R 100.0   0.0   0:00.25 binSear+
 413842 root      20   0   10264   6912   2816 R 100.0   0.0   0:00.25 binSear+
 413843 root      20   0   10264   6912   2816 R 100.0   0.0   0:00.24 binSear+
 413844 root      20   0   10264   7040   2944 R 100.0   0.0   0:00.25 binSear+
 413845 root      20   0   10264   7040   2944 R 100.0   0.0   0:00.23 binSear+
 413847 root      20   0   10264   7040   2944 R 100.0   0.0   0:00.25 binSear+
 413849 root      20   0   10264   7040   2944 R 100.0   0.0   0:00.24 binSear+
 413836 root      20   0   10264   6912   2816 R  92.3   0.0   0:00.24 binSear+
 413838 root      20   0   10264   7040   2944 R  92.3   0.0   0:00.24 binSear+
 413848 root      20   0   10264   7040   2944 R  92.3   0.0   0:00.23 binSear+
 413846 root      20   0   10264   7040   2944 R  84.6   0.0   0:00.22 binSear+
 413840 root      20   0   10264   7040   2944 R  69.2   0.0   0:00.18 binSear+
```



50000000 итераций

logs > double > binSearch > ltrace.log

```
% time     seconds  usecs/call     calls      function
------ ----------- ----------- --------- --------------------
 80.04    0.000730         730         1 _ZdlPvm
 11.51    0.000105         105         1 _Znwm
  8.44    0.000077          77         1 atoi
------ ----------- ----------- --------- --------------------
100.00    0.000912                     3 total
```

logs > double > binSearch > strace.log

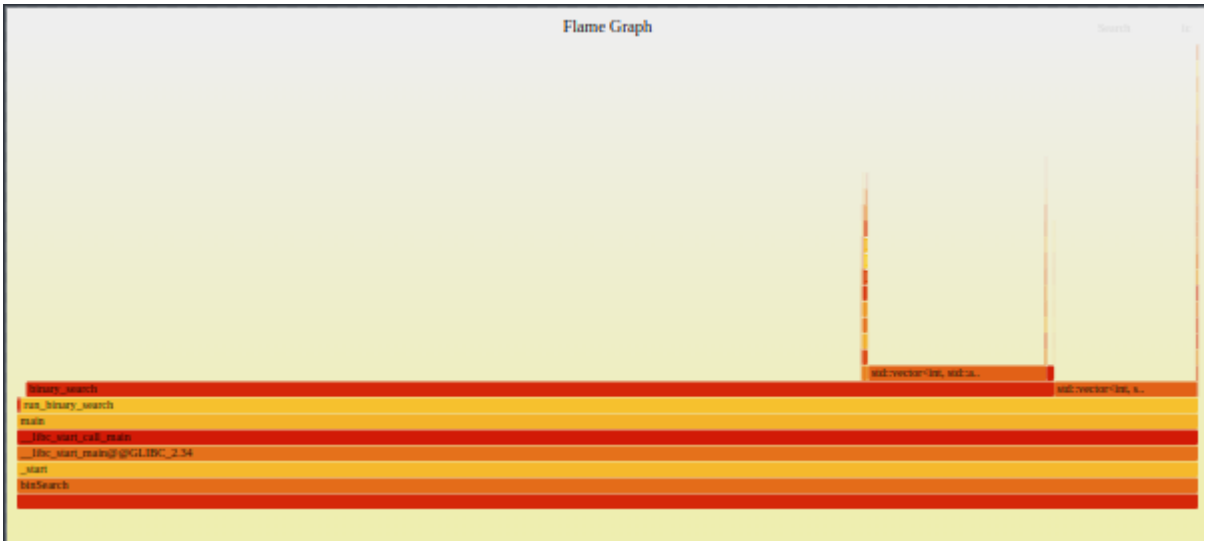
```
% time     seconds  usecs/call     calls    errors syscall
------ ----------- ----------- --------- --------- ----------------
 34.57    0.000065          10         6           mprotect
 30.32    0.000057           2        23           mmap
 10.64    0.000020           6         3           brk
 10.11    0.000019           9         2           munmap
  2.66    0.000005           5         1           getrandom
  2.13    0.000004           0         5           close
  1.60    0.000003           3         1           arch_prctl
  1.60    0.000003           3         1           futex
  1.60    0.000003           3         1           set_tid_address
  1.60    0.000003           3         1           set_robust_list
  1.60    0.000003           3         1           prlimit64
  1.60    0.000003           3         1           rseq
  0.00    0.000000           0         4           read
  0.00    0.000000           0         5           fstat
  0.00    0.000000           0         2           pread64
  0.00    0.000000           0         1         1 access
  0.00    0.000000           0         1           execve
  0.00    0.000000           0         5           openat
------ ----------- ----------- --------- --------- ----------------
100.00    0.000188           2        64         1 total
```

logs > double > binSearch > perf.log

```
Performance counter stats for './../exec/binSearch 50000000':

          3,375.63 msec task-clock                       #    0.999 CPUs utilized
               139      context-switches                 #   41.178 /sec
                30      cpu-migrations                   #    8.887 /sec
             1,103      page-faults                      #  326.754 /sec
    14,900,470,193      cycles                           #    4.414 GHz                         (42.83%)
        79,947,034      stalled-cycles-frontend          #    0.54% frontend cycles idle        (42.86%)
    59,551,247,218      instructions                     #    4.00  insn per cycle
                                                  #    0.00  stalled cycles per insn     (42.90%)
     6,857,971,471      branches                         #    2.032 G/sec                       (42.92%)
         1,781,780      branch-misses                    #    0.03% of all branches             (42.94%)
    19,650,819,679      L1-dcache-loads                  #    5.821 G/sec                       (42.94%)
         1,519,618      L1-dcache-load-misses            #    0.01% of all L1-dcache accesses   (42.90%)
   <not supported>      LLC-loads
   <not supported>      LLC-load-misses
        31,052,588      L1-icache-loads                  #    9.199 M/sec                       (42.87%)
            35,343      L1-icache-load-misses            #    0.11% of all L1-icache accesses   (42.84%)
           126,701      dTLB-loads                       #   37.534 K/sec                       (42.81%)
             7,383      dTLB-load-misses                 #    5.83% of all dTLB cache accesses  (42.80%)
               742      iTLB-loads                       #  219.811 /sec                        (42.80%)
             8,441      iTLB-load-misses                 # 1137.60% of all iTLB cache accesses  (42.80%)
           285,216      L1-dcache-prefetches             #   84.493 K/sec                       (42.79%)
   <not supported>      L1-dcache-prefetch-misses

       3.379408925 seconds time elapsed

       3.372080000 seconds user
       0.003997000 seconds sys
```

logs > double > binSearch > top.log

```
top - 07:15:36 up 2 days, 19:27,  1 user,  load average: 2.13, 2.61, 2.22
Tasks: 469 total,  18 running, 395 sleeping,  56 stopped,   0 zombie
%Cpu(s): 94.0 us,  5.6 sy,  0.0 ni,  0.0 id,  0.5 wa,  0.0 hi,  0.0 si,  0.0 st
MiB Mem :  15808.0 total,   1081.5 free,   5280.6 used,   9948.1 buff/cache
MiB Swap:   4096.0 total,   4094.2 free,      1.8 used.  10527.4 avail Mem

    PID USER      PR  NI    VIRT    RES    SHR S  %CPU  %MEM     TIME+ COMMAND
 415177 root      20   0   10264   7040   2944 R 100.0   0.0   0:00.25 binSear+
 415169 root      20   0   10264   6784   2688 R 100.0   0.0   0:00.25 binSear+
 415173 root      20   0   10264   7040   2944 R 100.0   0.0   0:00.25 binSear+
 415179 root      20   0   10264   6912   2816 R 100.0   0.0   0:00.25 binSear+
 415180 root      20   0   10264   7040   2944 R 100.0   0.0   0:00.23 binSear+
 415182 root      20   0   10264   6784   2688 R 100.0   0.0   0:00.25 binSear+
 415183 root      20   0   10264   6784   2688 R 100.0   0.0   0:00.24 binSear+
 415168 root      20   0   10264   6784   2688 R  92.3   0.0   0:00.23 binSear+
 415171 root      20   0   10264   7040   2944 R  92.3   0.0   0:00.25 binSear+
 415174 root      20   0   10264   7040   2944 R  92.3   0.0   0:00.23 binSear+
 415175 root      20   0   10264   7040   2944 R  92.3   0.0   0:00.25 binSear+
 415178 root      20   0   10264   7040   2944 R  92.3   0.0   0:00.24 binSear+
 415170 root      20   0   10264   7040   2944 R  84.6   0.0   0:00.23 binSear+
 415172 root      20   0   10264   7040   2944 R  84.6   0.0   0:00.23 binSear+
 415176 root      20   0   10264   7040   2944 R  84.6   0.0   0:00.23 binSear+
 415181 root      20   0   10264   7040   2944 R  84.6   0.0   0:00.21 binSear+
```



75000000 итераций

logs > triple > binSearch > ltrace.log

```
% time     seconds  usecs/call     calls      function
------ ----------- ----------- --------- --------------------
 63.77    0.000544         544         1 _ZdlPvm
 19.23    0.000164         164         1 _Znwm
 17.00    0.000145         145         1 atoi
------ ----------- ----------- --------- --------------------
100.00    0.000853                     3 total
```

logs > triple > binSearch > strace.log

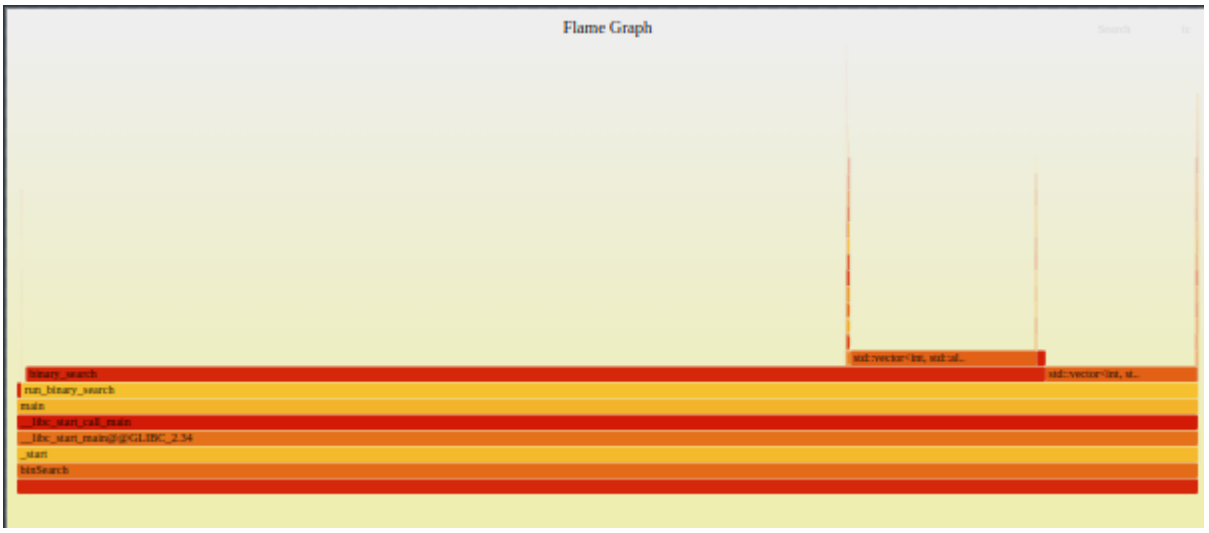
```
% time     seconds  usecs/call     calls    errors syscall
------ ----------- ----------- --------- --------- ----------------
  0.00    0.000000           0         4           read
  0.00    0.000000           0         5           close
  0.00    0.000000           0         5           fstat
  0.00    0.000000           0        23           mmap
  0.00    0.000000           0         6           mprotect
  0.00    0.000000           0         2           munmap
  0.00    0.000000           0         3           brk
  0.00    0.000000           0         2           pread64
  0.00    0.000000           0         1         1 access
  0.00    0.000000           0         1           execve
  0.00    0.000000           0         1           arch_prctl
  0.00    0.000000           0         1           futex
  0.00    0.000000           0         1           set_tid_address
  0.00    0.000000           0         5           openat
  0.00    0.000000           0         1           set_robust_list
  0.00    0.000000           0         1           prlimit64
  0.00    0.000000           0         1           getrandom
  0.00    0.000000           0         1           rseq
------ ----------- ----------- --------- --------- ----------------
100.00    0.000000           0        64         1 total
```

logs > triple > binSearch > perf.log

```
Performance counter stats for './../exec/binSearch 75000000':

          5,000.90 msec task-clock                       #    0.999 CPUs utilized
                67      context-switches                 #   13.398 /sec
                20      cpu-migrations                   #    3.999 /sec
             1,101      page-faults                      #  220.160 /sec
    22,313,757,267      cycles                           #    4.462 GHz                         (42.81%)
       122,035,904      stalled-cycles-frontend          #    0.55% frontend cycles idle        (42.84%)
    89,360,759,918      instructions                     #    4.00  insn per cycle
                                                     #    0.00  stalled cycles per insn     (42.88%)
    10,289,543,934      branches                         #    2.058 G/sec                       (42.92%)
         2,346,934      branch-misses                    #    0.02% of all branches             (42.92%)
    29,438,138,984      L1-dcache-loads                  #    5.887 G/sec                       (42.91%)
         1,705,017      L1-dcache-load-misses            #    0.01% of all L1-dcache accesses   (42.91%)
   <not supported>      LLC-loads
   <not supported>      LLC-load-misses
        43,146,018      L1-icache-loads                  #    8.628 M/sec                       (42.90%)
            44,799      L1-icache-load-misses            #    0.10% of all L1-icache accesses   (42.86%)
            46,112      dTLB-loads                       #    9.221 K/sec                       (42.81%)
             5,722      dTLB-load-misses                 #   12.41% of all dTLB cache accesses  (42.81%)
             1,193      iTLB-loads                       #  238.557 /sec                        (42.81%)
            10,613      iTLB-load-misses                 #  889.61% of all iTLB cache accesses  (42.81%)
           285,011      L1-dcache-prefetches             #   56.992 K/sec                       (42.81%)
   <not supported>      L1-dcache-prefetch-misses

      5.004799608 seconds time elapsed

      4.994616000 seconds user
      0.006998000 seconds sys
```

logs > triple > binSearch > top.log

```
top - 07:20:12 up 2 days, 19:31,  1 user,  load average: 1.93, 2.50, 2.30
Tasks: 481 total,  17 running, 408 sleeping,  56 stopped,   0 zombie
%Cpu(s): 90.7 us,  9.3 sy,  0.0 ni,  0.0 id,  0.0 wa,  0.0 hi,  0.0 si,  0.0 st
MiB Mem :  15808.0 total,    848.4 free,   5306.8 used,  10138.2 buff/cache
MiB Swap:   4096.0 total,   4094.2 free,      1.8 used.  10501.2 avail Mem

    PID USER      PR  NI    VIRT    RES    SHR S  %CPU  %MEM     TIME+ COMMAND
 417583 root      20   0   10264   6912   2816 R 100.0   0.0   0:00.25 binSear+
 417584 root      20   0   10264   6912   2816 R 100.0   0.0   0:00.27 binSear+
 417585 root      20   0   10264   7168   3072 R 100.0   0.0   0:00.26 binSear+
 417586 root      20   0   10264   7040   2944 R 100.0   0.0   0:00.27 binSear+
 417587 root      20   0   10264   7040   2944 R 100.0   0.0   0:00.23 binSear+
 417588 root      20   0   10264   7040   2944 R 100.0   0.0   0:00.27 binSear+
 417589 root      20   0   10264   7168   3072 R 100.0   0.0   0:00.27 binSear+
 417590 root      20   0   10264   7168   3072 R 100.0   0.0   0:00.26 binSear+
 417591 root      20   0   10264   7040   2944 R 100.0   0.0   0:00.27 binSear+
 417593 root      20   0   10264   7040   2944 R 100.0   0.0   0:00.27 binSear+
 417594 root      20   0   10264   7168   3072 R 100.0   0.0   0:00.25 binSear+
 417596 root      20   0   10264   7040   2944 R 100.0   0.0   0:00.25 binSear+
 417597 root      20   0   10264   6912   2816 R  92.3   0.0   0:00.24 binSear+
 417598 root      20   0   10264   7040   2944 R  92.3   0.0   0:00.24 binSear+
 417592 root      20   0   10264   7168   3072 R  84.6   0.0   0:00.23 binSear+
 417595 root      20   0   10264   7040   2944 R  76.9   0.0   0:00.21 binSear+
```



100000000 итераций

logs > quad > binSearch > ltrace.log

```
% time     seconds  usecs/call     calls      function
------ ----------- ----------- --------- --------------------
 74.97    0.000659         659         1 _ZdlPvm
 12.86    0.000113         113         1 _Znwm
 12.17    0.000107         107         1 atoi
------ ----------- ----------- --------- --------------------
100.00    0.000879                     3 total
```

logs > quad > binSearch > strace.log

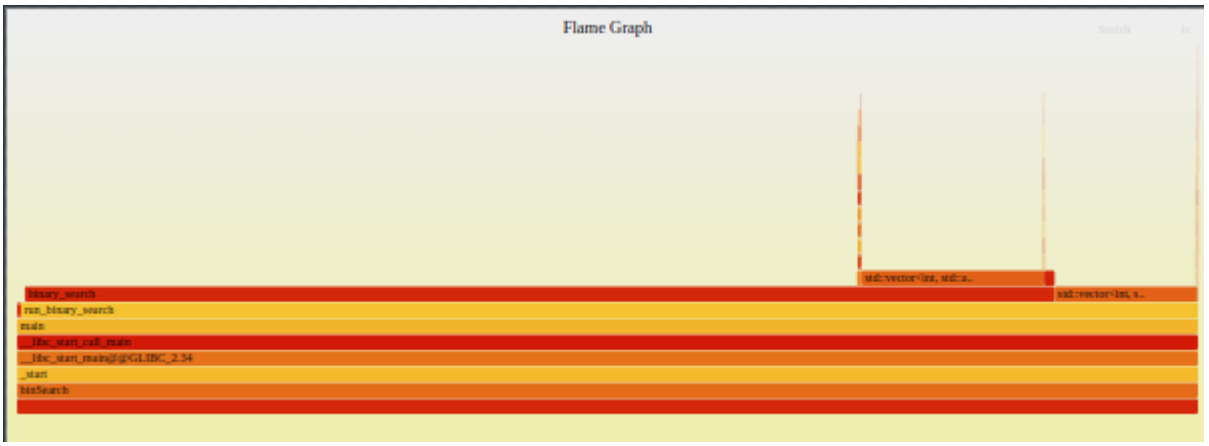
```
% time     seconds  usecs/call     calls    errors syscall
------ ----------- ----------- --------- --------- ----------------
 57.20    0.000528         264         2           munmap
 22.97    0.000212           9        23           mmap
  6.28    0.000058           9         6           mprotect
  3.90    0.000036           7         5           openat
  1.95    0.000018           3         5           fstat
  1.73    0.000016           4         4           read
  1.41    0.000013           2         5           close
  1.41    0.000013           4         3           brk
  0.65    0.000006           3         2           pread64
  0.43    0.000004           4         1           prlimit64
  0.43    0.000004           4         1           getrandom
  0.33    0.000003           3         1           arch_prctl
  0.33    0.000003           3         1           futex
  0.33    0.000003           3         1           set_tid_address
  0.33    0.000003           3         1           set_robust_list
  0.33    0.000003           3         1           rseq
  0.00    0.000000           0         1         1 access
  0.00    0.000000           0         1           execve
------ ----------- ----------- --------- --------- ----------------
100.00    0.000923          14        64         1 total
```

logs > quad > binSearch > perf.log

```
Performance counter stats for './../exec/binSearch 100000000':

          6,663.38 msec task-clock                       #    0.999 CPUs utilized
               220      context-switches                 #   33.016 /sec
                36      cpu-migrations                   #    5.403 /sec
             1,103      page-faults                      #  165.532 /sec
    29,754,445,059      cycles                           #    4.465 GHz                         (42.83%)
       167,724,146      stalled-cycles-frontend          #    0.56% frontend cycles idle        (42.82%)
   119,084,943,763      instructions                     #    4.00  insn per cycle
                                                   #    0.00  stalled cycles per insn     (42.82%)
    13,712,195,156      branches                         #    2.058 G/sec                       (42.85%)
         2,902,012      branch-misses                    #    0.02% of all branches             (42.85%)
    39,276,752,507      L1-dcache-loads                  #    5.894 G/sec                       (42.86%)
         1,913,348      L1-dcache-load-misses            #    0.00% of all L1-dcache accesses   (42.88%)
   <not supported>      LLC-loads
   <not supported>      LLC-load-misses
        53,170,830      L1-icache-loads                  #    7.980 M/sec                       (42.89%)
            65,734      L1-icache-load-misses            #    0.12% of all L1-icache accesses   (42.89%)
            43,150      dTLB-loads                       #    6.476 K/sec                       (42.86%)
             6,322      dTLB-load-misses                 #   14.65% of all dTLB cache accesses  (42.88%)
               634      iTLB-loads                       #   95.147 /sec                        (42.88%)
            14,268      iTLB-load-misses                 # 2250.47% of all iTLB cache accesses  (42.86%)
           354,964      L1-dcache-prefetches             #   53.271 K/sec                       (42.84%)
   <not supported>      L1-dcache-prefetch-misses

       6.670455431 seconds time elapsed

       6.659930000 seconds user
       0.004000000 seconds sys
```

logs > quad > binSearch > top.log

```
top - 07:26:49 up 2 days, 19:38,  1 user,  load average: 3.40, 3.06, 2.60
Tasks: 474 total,  17 running, 401 sleeping,  56 stopped,   0 zombie
%Cpu(s): 91.6 us,  8.0 sy,  0.0 ni,  0.0 id,  0.0 wa,  0.0 hi,  0.4 si,  0.0 st
MiB Mem :  15808.0 total,    669.9 free,   5575.7 used,  10107.8 buff/cache
MiB Swap:   4096.0 total,   4094.2 free,      1.8 used.  10232.3 avail Mem

    PID USER      PR  NI    VIRT    RES    SHR S  %CPU  %MEM     TIME+ COMMAND
 420045 root      20   0   10264   6912   2816 R  92.9   0.0   0:00.26 binSear+
 420046 root      20   0   10264   6912   2816 R  92.9   0.0   0:00.27 binSear+
 420047 root      20   0   10264   7040   2944 R  92.9   0.0   0:00.27 binSear+
 420048 root      20   0   10264   7040   2944 R  92.9   0.0   0:00.27 binSear+
 420049 root      20   0   10264   7040   2944 R  92.9   0.0   0:00.26 binSear+
 420051 root      20   0   10264   7040   2944 R  92.9   0.0   0:00.27 binSear+
 420053 root      20   0   10264   7168   3072 R  92.9   0.0   0:00.27 binSear+
 420055 root      20   0   10264   7040   2944 R  92.9   0.0   0:00.26 binSear+
 420056 root      20   0   10264   7168   3072 R  92.9   0.0   0:00.26 binSear+
 420052 root      20   0   10264   7040   2944 R  85.7   0.0   0:00.25 binSear+
 420057 root      20   0   10264   7168   3072 R  85.7   0.0   0:00.24 binSear+
 420058 root      20   0   10264   7168   3072 R  85.7   0.0   0:00.24 binSear+
 420059 root      20   0   10264   7040   2944 R  85.7   0.0   0:00.24 binSear+
 420060 root      20   0   10264   7168   3072 R  85.7   0.0   0:00.21 binSear+
 420050 root      20   0   10264   7168   3072 R  78.6   0.0   0:00.23 binSear+
 420054 root      20   0   10264   7040   2944 R  78.6   0.0   0:00.23 binSear+
```



---

io-lat-read

25000 итераций

logs > single > ioLatRead > ltrace.log

```
% time     seconds  usecs/call     calls      function
------ ----------- ----------- --------- --------------------
 30.41    5.931792          59    100000 _ZNSi4readEPcl
 25.77    5.026017          50    100000 _ZNKSt9basic_iosIcSt11char_traitsIcEEcvbEv
 12.85    2.506475          50     50000 _ZNKSi6gcountEv
  9.23    1.800042          72     25000 _ZNSt14basic_ifstreamIcSt11char_traitsIcEEC1EPKcSt13_Ios_Openmode
  8.78    1.711797          68     25000 _ZNSt14basic_ifstreamIcSt11char_traitsIcEE5closeEv
  6.49    1.265882          50     25000 _ZNKSt9basic_iosIcSt11char_traitsIcEEntEv
  6.48    1.263351          50     25000 _ZNSt14basic_ifstreamIcSt11char_traitsIcEED1Ev
  0.00    0.000091          91         1 atoi
------ ----------- ----------- --------- --------------------
100.00   19.505447               350001 total
```

logs > single > ioLatRead > strace.log

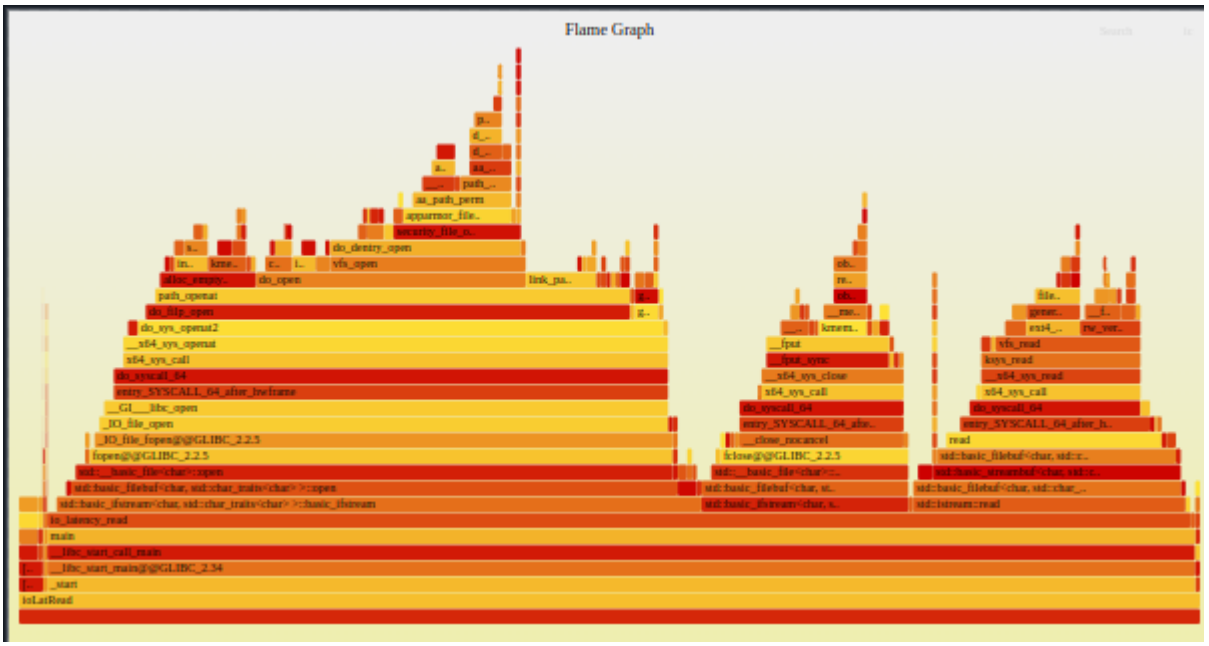
```
% time     seconds  usecs/call     calls    errors syscall
------ ----------- ----------- --------- --------- ----------------
 44.01    0.174406           3     50004           read
 34.14    0.135306           5     25005           openat
 21.83    0.086516           3     25005           close
  0.01    0.000059           9         6           mprotect
  0.00    0.000016          16         1           munmap
  0.00    0.000011           3         3           brk
  0.00    0.000004           4         1           futex
  0.00    0.000004           4         1           prlimit64
  0.00    0.000004           4         1           getrandom
  0.00    0.000000           0         5           fstat
  0.00    0.000000           0        22           mmap
  0.00    0.000000           0         2           pread64
  0.00    0.000000           0         1         1 access
  0.00    0.000000           0         1           execve
  0.00    0.000000           0         1           arch_prctl
  0.00    0.000000           0         1           set_tid_address
  0.00    0.000000           0         1           set_robust_list
  0.00    0.000000           0         1           rseq
------ ----------- ----------- --------- --------- ----------------
100.00    0.396326           3    100062         1 total
```

logs > single > ioLatRead > perf.log

```
Performance counter stats for './../exec/ioLatRead ./../shell.cpp 25000':

            122.13 msec task-clock                       #    0.991 CPUs utilized
                25      context-switches                 #  204.697 /sec
                 5      cpu-migrations                   #   40.939 /sec
               128      page-faults                      #    1.048 K/sec
       541,074,233      cycles                           #    4.430 GHz                         (41.32%)
       191,127,701      stalled-cycles-frontend          #   35.32% frontend cycles idle        (41.31%)
       480,386,912      instructions                     #    0.89  insn per cycle
                                                   #    0.40  stalled cycles per insn     (41.52%)
       101,249,064      branches                         #  829.017 M/sec                       (42.37%)
        10,525,859      branch-misses                    #   10.40% of all branches             (43.07%)
       198,490,852      L1-dcache-loads                  #    1.625 G/sec                        (43.87%)
         2,902,866      L1-dcache-load-misses            #    1.46% of all L1-dcache accesses   (43.97%)
   <not supported>      LLC-loads
   <not supported>      LLC-load-misses
       204,161,354      L1-icache-loads                  #    1.672 G/sec                        (43.99%)
         1,081,319      L1-icache-load-misses            #    0.53% of all L1-icache accesses   (43.95%)
         1,605,170      dTLB-loads                       #   13.143 M/sec                        (43.99%)
             3,094      dTLB-load-misses                 #    0.19% of all dTLB cache accesses  (43.92%)
            10,843      iTLB-loads                       #   88.781 K/sec                        (43.04%)
           410,276      iTLB-load-misses                 # 3783.79% of all iTLB cache accesses  (42.24%)
           414,702      L1-dcache-prefetches             #    3.396 M/sec                        (41.43%)
   <not supported>      L1-dcache-prefetch-misses

       0.123227630 seconds time elapsed

       0.028915000 seconds user
       0.093725000 seconds sys
```

logs > single > ioLatRead > top.log

```
1   top - 07:13:47 up 2 days, 19:25,  1 user,  load average: 3.08, 2.82, 2.23
2   Tasks: 461 total,   1 running, 404 sleeping,  56 stopped,   0 zombie
3   %Cpu(s): 17.7 us, 81.8 sy,  0.5 ni,  0.0 id,  0.0 wa,  0.0 hi,  0.0 si,  0.0 st
4   MiB Mem :  15808.0 total,    994.5 free,   5374.6 used,   9948.0 buff/cache
5   MiB Swap:   4096.0 total,   4094.2 free,      1.8 used.  10433.4 avail Mem
6
7       PID USER      PR  NI    VIRT    RES    SHR S  %CPU  %MEM     TIME+ COMMAND
8    340250 junayd    20   0 1161.7g 447584 111324 S   7.7   2.8  14:18.61 code
9    361992 junayd    20   0   32.4g 171952 121120 S   7.7   1.1   2:39.34 code
10   413971 junayd    20   0 1159.6g 309884 129960 S   7.7   1.9   0:03.77 chrome
11         1 root     20   0   23640  14328   9080 S   0.0   0.1   0:16.99 systemd
12         2 root     20   0       0      0      0 S   0.0   0.0   0:00.16 kthreadd
13         3 root     20   0       0      0      0 S   0.0   0.0   0:00.00 pool_wo+
14         4 root      0 -20       0      0      0 I   0.0   0.0   0:00.00 kworker+
15         5 root      0 -20       0      0      0 I   0.0   0.0   0:00.00 kworker+
16         6 root      0 -20       0      0      0 I   0.0   0.0   0:00.00 kworker+
17         7 root      0 -20       0      0      0 I   0.0   0.0   0:00.00 kworker+
18        10 root      0 -20       0      0      0 I   0.0   0.0   0:00.00 kworker+
19        12 root      0 -20       0      0      0 I   0.0   0.0   0:00.00 kworker+
20        13 root     20   0       0      0      0 I   0.0   0.0   0:00.00 rcu_tas+
21        14 root     20   0       0      0      0 I   0.0   0.0   0:00.00 rcu_tas+
22        15 root     20   0       0      0      0 I   0.0   0.0   0:00.00 rcu_tas+
23        16 root     20   0       0      0      0 S   0.0   0.0   0:02.23 ksoftir+
24        17 root     20   0       0      0      0 I   0.0   0.0   1:16.29 rcu_pre+
25        18 root     rt   0       0      0      0 S   0.0   0.0   0:33.40 migrati+
26        19 root    -51   0       0      0      0 S   0.0   0.0   0:00.00 idle_in+
27        20 root     20   0       0      0      0 S   0.0   0.0   0:00.00 cpuhp/0
28        21 root     20   0       0      0      0 S   0.0   0.0   0:00.00 cpuhp/2
```



50000 итераций

logs > double > ioLatRead > ltrace.log

```
% time     seconds  usecs/call     calls      function
------ ----------- ----------- --------- --------------------
 30.41   12.380289          61    200000 _ZNSi4readEPcl
 25.77   10.491491          52    200000 _ZNKSt9basic_iosIcSt11char_traitsIcEEcvbEv
 12.84    5.229556          52    100000 _ZNKSi6gcountEv
  9.25    3.765709          75     50000 _ZNSt14basic_ifstreamIcSt11char_traitsIcEEC1EPKcSt13_Ios_Openmode
  8.80    3.582430          71     50000 _ZNSt14basic_ifstreamIcSt11char_traitsIcEE5closeEv
  6.47    2.635201          52     50000 _ZNSt14basic_ifstreamIcSt11char_traitsIcEED1Ev
  6.46    2.631886          52     50000 _ZNKSt9basic_iosIcSt11char_traitsIcEEntEv
  0.00    0.000102         102         1 atoi
------ ----------- ----------- --------- --------------------
100.00   40.716664               700001 total
```

logs > double > ioLatRead > strace.log

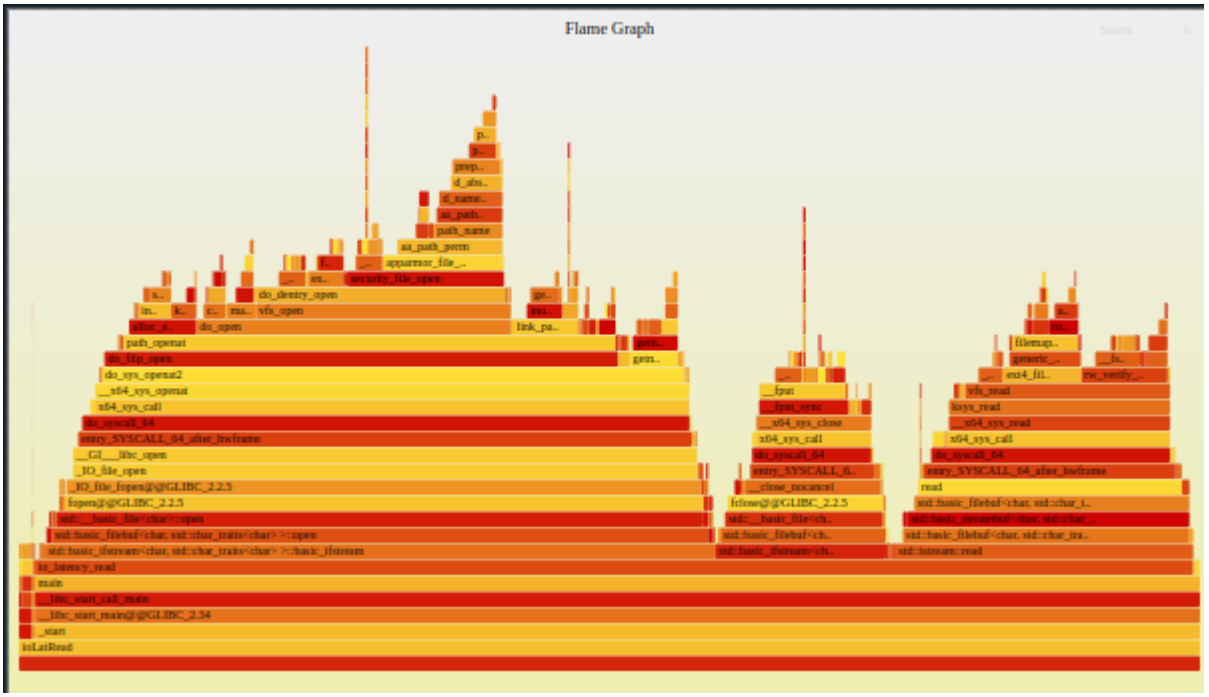
```
% time     seconds  usecs/call     calls    errors syscall
------ ----------- ----------- --------- --------- ----------------
 43.64    0.345565           3    100004           read
 34.23    0.270991           5     50005           openat
 22.00    0.174228           3     50005           close
  0.06    0.000456         456         1           execve
  0.04    0.000353          16        22           mmap
  0.01    0.000053           8         6           mprotect
  0.00    0.000038           7         5           fstat
  0.00    0.000021           7         3           brk
  0.00    0.000016          16         1           munmap
  0.00    0.000010          10         1         1 access
  0.00    0.000008           4         2           pread64
  0.00    0.000005           5         1           set_tid_address
  0.00    0.000005           5         1           getrandom
  0.00    0.000005           5         1           rseq
  0.00    0.000004           4         1           arch_prctl
  0.00    0.000004           4         1           prlimit64
  0.00    0.000003           3         1           futex
  0.00    0.000002           2         1           set_robust_list
------ ----------- ----------- --------- --------- ----------------
100.00    0.791767           3    200062         1 total
```

logs > double > ioLatRead > perf.log

```
Performance counter stats for './../exec/ioLatRead ./../shell.cpp 50000':

            264.93 msec task-clock                       #    0.993 CPUs utilized
                48      context-switches                 #  181.178 /sec
                 3      cpu-migrations                   #   11.324 /sec
               128      page-faults                      #  483.142 /sec
     1,149,138,896      cycles                           #    4.337 GHz                         (42.19%)
       430,527,068      stalled-cycles-frontend          #   37.47% frontend cycles idle        (41.78%)
       945,052,377      instructions                     #    0.82  insn per cycle
                                                   #    0.46  stalled cycles per insn     (41.82%)
       198,564,371      branches                         #  749.491 M/sec                       (41.83%)
        20,740,451      branch-misses                    #   10.45% of all branches             (42.17%)
       392,743,734      L1-dcache-loads                  #    1.482 G/sec                        (42.94%)
         7,246,217      L1-dcache-load-misses            #    1.85% of all L1-dcache accesses   (43.17%)
   <not supported>      LLC-loads
   <not supported>      LLC-load-misses
       404,011,217      L1-icache-loads                  #    1.525 G/sec                        (43.58%)
         2,236,903      L1-icache-load-misses            #    0.55% of all L1-icache accesses   (43.54%)
         3,496,082      dTLB-loads                       #   13.196 M/sec                        (43.95%)
            25,451      dTLB-load-misses                 #    0.73% of all dTLB cache accesses  (43.94%)
            86,960      iTLB-loads                       #  328.235 K/sec                        (43.52%)
           817,432      iTLB-load-misses                 #  940.01% of all iTLB cache accesses  (43.17%)
         1,183,933      L1-dcache-prefetches             #    4.469 M/sec                        (42.40%)
   <not supported>      L1-dcache-prefetch-misses

       0.266817308 seconds time elapsed

       0.048400000 seconds user
       0.216793000 seconds sys
```

logs > double > ioLatRead > top.log

```
top - 07:16:52 up 2 days, 19:28,  1 user,  load average: 2.61, 2.73, 2.30
Tasks: 486 total,  19 running, 411 sleeping,  56 stopped,   0 zombie
%Cpu(s): 15.6 us, 84.4 sy,  0.0 ni,  0.0 id,  0.0 wa,  0.0 hi,  0.0 si,  0.0 st
MiB Mem :  15808.0 total,    877.0 free,   5246.2 used,  10183.5 buff/cache
MiB Swap:   4096.0 total,   4094.2 free,      1.8 used.  10561.8 avail Mem

    PID USER      PR  NI    VIRT    RES    SHR S  %CPU  %MEM     TIME+ COMMAND
 416251 root      20   0    6356   3072   2944 R 100.0   0.0   0:00.27 ioLatRe+
 416250 root      20   0    6356   3200   3072 R 100.0   0.0   0:00.26 ioLatRe+
 416258 root      20   0    6356   3328   3200 R 100.0   0.0   0:00.26 ioLatRe+
 416260 root      20   0    6356   3328   3200 R 100.0   0.0   0:00.26 ioLatRe+
 416263 root      20   0    6356   3328   3200 R 100.0   0.0   0:00.26 ioLatRe+
 416264 root      20   0    6356   3328   3200 R 100.0   0.0   0:00.26 ioLatRe+
 416265 root      20   0    6356   3328   3200 R 100.0   0.0   0:00.26 ioLatRe+
 416252 root      20   0    6356   3200   3072 R  92.9   0.0   0:00.26 ioLatRe+
 416253 root      20   0    6356   3200   3072 R  92.9   0.0   0:00.26 ioLatRe+
 416254 root      20   0    6356   3328   3200 R  92.9   0.0   0:00.24 ioLatRe+
 416255 root      20   0    6356   3328   3200 R  92.9   0.0   0:00.26 ioLatRe+
 416257 root      20   0    6356   3328   3200 R  92.9   0.0   0:00.25 ioLatRe+
 416261 root      20   0    6356   3328   3200 R  92.9   0.0   0:00.26 ioLatRe+
 416259 root      20   0    6356   3328   3200 R  85.7   0.0   0:00.25 ioLatRe+
 416262 root      20   0    6356   3328   3200 R  85.7   0.0   0:00.25 ioLatRe+
 416256 root      20   0    6356   3328   3200 R  71.4   0.0   0:00.19 ioLatRe+
```



75000 итераций

logs > triple > ioLatRead > ltrace.log

```
% time     seconds  usecs/call     calls      function
------ ----------- ----------- --------- --------------------
 30.39   18.200454          60    300000 _ZNSi4readEPcl
 25.75   15.421275          51    300000 _ZNKSt9basic_iosIcSt11char_traitsIcEEcvbEv
 12.83    7.684593          51    150000 _ZNKSi6gcountEv
  9.28    5.556695          74     75000 _ZNSt14basic_ifstreamIcSt11char_traitsIcEEC1EPKcSt13_Ios_Openmode
  8.82    5.281894          70     75000 _ZNSt14basic_ifstreamIcSt11char_traitsIcEE5closeEv
  6.48    3.879227          51     75000 _ZNSt14basic_ifstreamIcSt11char_traitsIcEED1Ev
  6.47    3.873455          51     75000 _ZNKSt9basic_iosIcSt11char_traitsIcEEntEv
  0.00    0.000200         200         1 atoi
------ ----------- ----------- --------- --------------------
100.00   59.897793               1050001 total
```

logs > triple > ioLatRead > strace.log

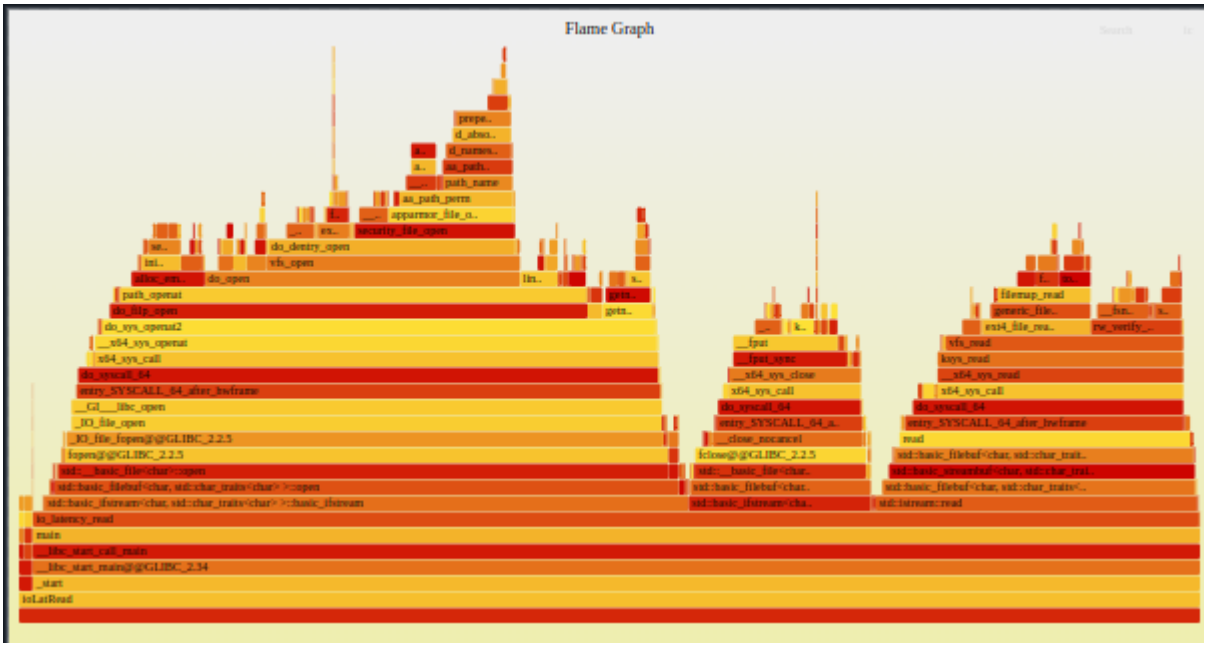
```
% time     seconds  usecs/call     calls    errors syscall
------ ----------- ----------- --------- --------- ----------------
 43.51    0.552764           3    150004           read
 34.76    0.441676           5     75005           openat
 21.70    0.275700           3     75005           close
  0.02    0.000198           9        22           mmap
  0.01    0.000072          12         6           mprotect
  0.00    0.000014          14         1           munmap
  0.00    0.000010           2         5           fstat
  0.00    0.000009           3         3           brk
  0.00    0.000003           3         1           arch_prctl
  0.00    0.000003           3         1           futex
  0.00    0.000003           3         1           set_tid_address
  0.00    0.000003           3         1           set_robust_list
  0.00    0.000003           3         1           prlimit64
  0.00    0.000003           3         1           getrandom
  0.00    0.000003           3         1           rseq
  0.00    0.000000           0         2           pread64
  0.00    0.000000           0         1         1 access
  0.00    0.000000           0         1           execve
------ ----------- ----------- --------- --------- ----------------
100.00    1.270464           4    300062         1 total
```

logs > triple > ioLatRead > perf.log

```
Performance counter stats for './../exec/ioLatRead ./../shell.cpp 75000':

            355.06 msec task-clock                       #    0.998 CPUs utilized
                13      context-switches                 #   36.614 /sec
                 4      cpu-migrations                   #   11.266 /sec
               129      page-faults                      #  363.322 /sec
     1,590,319,396      cycles                           #    4.479 GHz                         (42.38%)
       556,596,769      stalled-cycles-frontend          #   35.00% frontend cycles idle        (42.63%)
     1,420,881,301      instructions                     #    0.89  insn per cycle
                                                   #    0.39  stalled cycles per insn     (42.90%)
       299,246,096      branches                         #  842.812 M/sec                       (43.19%)
        31,104,185      branch-misses                    #   10.39% of all branches             (43.46%)
       587,569,721      L1-dcache-loads                  #    1.655 G/sec                        (43.69%)
         8,192,614      L1-dcache-load-misses            #    1.39% of all L1-dcache accesses   (43.57%)
   <not supported>      LLC-loads
   <not supported>      LLC-load-misses
       607,943,198      L1-icache-loads                  #    1.712 G/sec                        (43.32%)
         3,403,939      L1-icache-load-misses            #    0.56% of all L1-icache accesses   (43.02%)
         4,759,310      dTLB-loads                       #   13.404 M/sec                        (42.73%)
             9,641      dTLB-load-misses                 #    0.20% of all dTLB cache accesses  (42.46%)
            25,841      iTLB-loads                       #   72.780 K/sec                        (42.22%)
         1,233,287      iTLB-load-misses                 # 4772.60% of all iTLB cache accesses  (42.20%)
         1,145,403      L1-dcache-prefetches             #    3.226 M/sec                        (42.22%)
   <not supported>      L1-dcache-prefetch-misses

       0.355914915 seconds time elapsed

       0.063123000 seconds user
       0.292570000 seconds sys
```

logs > triple > ioLatRead > top.log

```
top - 07:22:03 up 2 days, 19:33,  1 user,  load average: 1.90, 2.51, 2.34
Tasks: 476 total,  19 running, 401 sleeping,  56 stopped,   0 zombie
%Cpu(s): 18.7 us, 80.9 sy,  0.0 ni,  0.5 id,  0.0 wa,  0.0 hi,  0.0 si,  0.0 st
MiB Mem :  15808.0 total,    864.1 free,   5288.3 used,  10152.0 buff/cache
MiB Swap:   4096.0 total,   4094.2 free,      1.8 used.  10519.7 avail Mem

    PID USER      PR  NI    VIRT    RES    SHR S  %CPU  %MEM     TIME+ COMMAND
 418201 root      20   0    6356   3328   3200 R 100.0   0.0   0:00.25 ioLatRe+
 418204 root      20   0    6356   3328   3200 R 100.0   0.0   0:00.25 ioLatRe+
 418205 root      20   0    6356   3328   3200 R 100.0   0.0   0:00.25 ioLatRe+
 418197 root      20   0    6356   3072   2944 R 100.0   0.0   0:00.24 ioLatRe+
 418198 root      20   0    6356   3072   2944 R 100.0   0.0   0:00.24 ioLatRe+
 418200 root      20   0    6356   3328   3200 R 100.0   0.0   0:00.25 ioLatRe+
 418203 root      20   0    6356   3200   3072 R 100.0   0.0   0:00.23 ioLatRe+
 418206 root      20   0    6356   3328   3200 R 100.0   0.0   0:00.23 ioLatRe+
 418207 root      20   0    6356   3200   3072 R 100.0   0.0   0:00.24 ioLatRe+
 418208 root      20   0    6356   3072   2944 R 100.0   0.0   0:00.24 ioLatRe+
 418209 root      20   0    6356   3200   3072 R 100.0   0.0   0:00.23 ioLatRe+
 418210 root      20   0    6356   3328   3200 R 100.0   0.0   0:00.24 ioLatRe+
 418199 root      20   0    6356   3328   3200 R  91.7   0.0   0:00.23 ioLatRe+
 418202 root      20   0    6356   3200   3072 R  91.7   0.0   0:00.24 ioLatRe+
 418211 root      20   0    6356   3328   3200 R  91.7   0.0   0:00.22 ioLatRe+
 418212 root      20   0    6356   3328   3200 R  83.3   0.0   0:00.22 ioLatRe+
```



100000 итераций

logs > quad > ioLatRead > ltrace.log

```
% time     seconds  usecs/call     calls      function
------ ----------- ----------- --------- --------------------
 30.40   24.399511          60    400000 _ZNSi4readEPcl
 25.73   20.654500          51    400000 _ZNKSt9basic_iosIcSt11char_traitsIcEEcvbEv
 12.82   10.292191          51    200000 _ZNKSi6gcountEv
  9.30    7.460884          74    100000 _ZNSt14basic_ifstreamIcSt11char_traitsIcEEC1EPKcSt13_Ios_Openmode
  8.83    7.089371          70    100000 _ZNSt14basic_ifstreamIcSt11char_traitsIcEE5closeEv
  6.47    5.196235          51    100000 _ZNSt14basic_ifstreamIcSt11char_traitsIcEED1Ev
  6.44    5.172988          51    100000 _ZNKSt9basic_iosIcSt11char_traitsIcEEntEv
  0.00    0.000205         205         1 atoi
------ ----------- ----------- --------- --------------------
100.00   80.265885               1400001 total
```

logs > quad > ioLatRead > strace.log

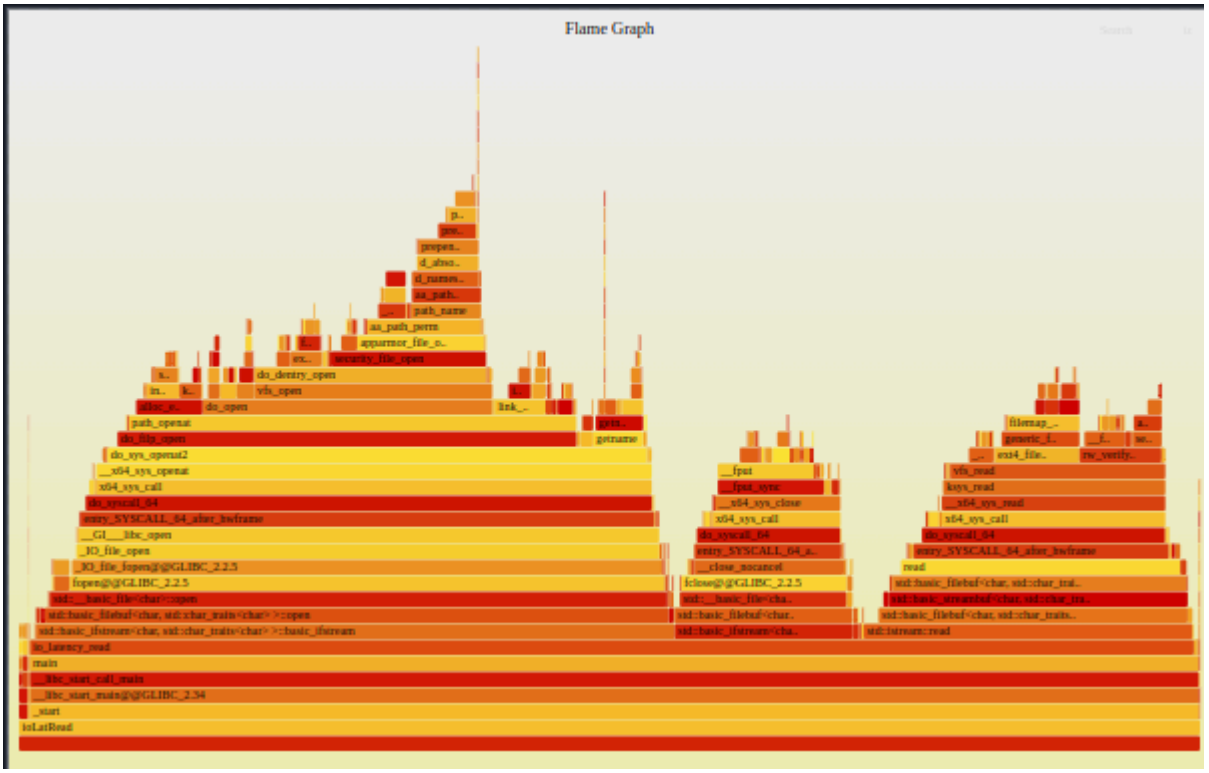
```
% time     seconds  usecs/call     calls    errors syscall
------ ----------- ----------- --------- --------- ----------------
 43.66    0.671964           3    200004           read
 34.57    0.532140           5    100005           openat
 21.72    0.334334           3    100005           close
  0.03    0.000405         405         1           execve
  0.01    0.000212           9        22           mmap
  0.00    0.000047           7         6           mprotect
  0.00    0.000030           6         5           fstat
  0.00    0.000025           8         3           brk
  0.00    0.000014          14         1         1 access
  0.00    0.000011          11         1           munmap
  0.00    0.000006           3         2           pread64
  0.00    0.000004           4         1           getrandom
  0.00    0.000003           3         1           arch_prctl
  0.00    0.000003           3         1           futex
  0.00    0.000003           3         1           set_tid_address
  0.00    0.000003           3         1           prlimit64
  0.00    0.000003           3         1           rseq
  0.00    0.000002           2         1           set_robust_list
------ ----------- ----------- --------- --------- ----------------
100.00    1.539209           3    400062         1 total
```

logs > quad > ioLatRead > perf.log

```

Performance counter stats for './../exec/ioLatRead ./../shell.cpp 100000':

            468.97 msec task-clock                       #    0.998 CPUs utilized
                12      context-switches                 #   25.588 /sec
                 7      cpu-migrations                   #   14.926 /sec
               127      page-faults                      #  270.807 /sec
     2,108,179,687      cycles                           #    4.495 GHz                         (42.27%)
       735,901,354      stalled-cycles-frontend          #   34.91% frontend cycles idle        (42.46%)
     1,901,090,038      instructions                     #    0.90  insn per cycle
                                                   #    0.39  stalled cycles per insn     (42.68%)
       400,290,404      branches                         #  853.556 M/sec                       (42.90%)
        41,475,666      branch-misses                    #   10.36% of all branches             (43.10%)
       781,817,176      L1-dcache-loads                  #    1.667 G/sec                        (43.33%)
        10,865,189      L1-dcache-load-misses            #    1.39% of all L1-dcache accesses   (43.45%)
   <not supported>      LLC-loads
   <not supported>      LLC-load-misses
       801,562,323      L1-icache-loads                  #    1.709 G/sec                        (43.46%)
         4,479,773      L1-icache-load-misses            #    0.56% of all L1-icache accesses   (43.25%)
         6,313,888      dTLB-loads                       #   13.463 M/sec                        (43.03%)
             8,901      dTLB-load-misses                 #    0.14% of all dTLB cache accesses  (42.82%)
            11,714      iTLB-loads                       #   24.978 K/sec                        (42.61%)
         1,598,429      iTLB-load-misses                 # 13645.46% of all iTLB cache accesses  (42.43%)
         1,769,444      L1-dcache-prefetches             #    3.773 M/sec                        (42.21%)
   <not supported>      L1-dcache-prefetch-misses

       0.469799354 seconds time elapsed

       0.084933000 seconds user
       0.384699000 seconds sys
```

logs > quad > ioLatRead > top.log

```
top - 07:29:14 up 2 days, 19:40,  1 user,  load average: 2.17, 3.12, 2.73
Tasks: 474 total,  18 running, 400 sleeping,  56 stopped,   0 zombie
%Cpu(s): 19.1 us, 80.9 sy,  0.0 ni,  0.0 id,  0.0 wa,  0.0 hi,  0.0 si,  0.0 st
MiB Mem :  15808.0 total,    787.4 free,   5452.9 used,  10088.5 buff/cache
MiB Swap:   4096.0 total,   4094.2 free,      1.8 used.  10355.1 avail Mem

    PID USER      PR  NI    VIRT    RES    SHR S  %CPU  %MEM     TIME+ COMMAND
 420691 root      20   0    6356   3200   3072 R 100.0   0.0   0:00.24 ioLatRe+
 420692 root      20   0    6356   3200   3072 R 100.0   0.0   0:00.25 ioLatRe+
 420694 root      20   0    6356   3328   3200 R 100.0   0.0   0:00.25 ioLatRe+
 420696 root      20   0    6356   3328   3200 R 100.0   0.0   0:00.24 ioLatRe+
 420690 root      20   0    6356   3200   3072 R  92.3   0.0   0:00.24 ioLatRe+
 420693 root      20   0    6356   3328   3200 R  92.3   0.0   0:00.24 ioLatRe+
 420695 root      20   0    6356   3328   3200 R  92.3   0.0   0:00.24 ioLatRe+
 420697 root      20   0    6356   3328   3200 R  92.3   0.0   0:00.24 ioLatRe+
 420698 root      20   0    6356   3328   3200 R  92.3   0.0   0:00.24 ioLatRe+
 420699 root      20   0    6356   3328   3200 R  92.3   0.0   0:00.22 ioLatRe+
 420700 root      20   0    6356   3328   3200 R  92.3   0.0   0:00.24 ioLatRe+
 420701 root      20   0    6356   3328   3200 R  92.3   0.0   0:00.24 ioLatRe+
 420702 root      20   0    6356   3328   3200 R  92.3   0.0   0:00.24 ioLatRe+
 420704 root      20   0    6356   3328   3200 R  92.3   0.0   0:00.23 ioLatRe+
 420689 root      20   0    6356   3072   2944 R  84.6   0.0   0:00.21 ioLatRe+
 420703 root      20   0    6356   3328   3200 R  84.6   0.0   0:00.23 ioLatRe+
```



---

both

25000000 | 25000 итераций

logs > single > both > ltrace.log

```
% time     seconds  usecs/call     calls      function
------ ----------- ----------- --------- --------------------
 99.99   33.428510    16714255         2 _ZNSt6thread4joinEv
  0.01    0.002059        1029         2 _ZNSt6thread15_M_start_threadESt10unique_ptrINS_6_StateESt14default_deleteIS1_EEPFvvE
  0.00    0.000212         106         2 _Znwm
  0.00    0.000147          73         2 atoi
------ ----------- ----------- --------- --------------------
100.00   33.430928                     8 total
```

logs > single > both > strace.log

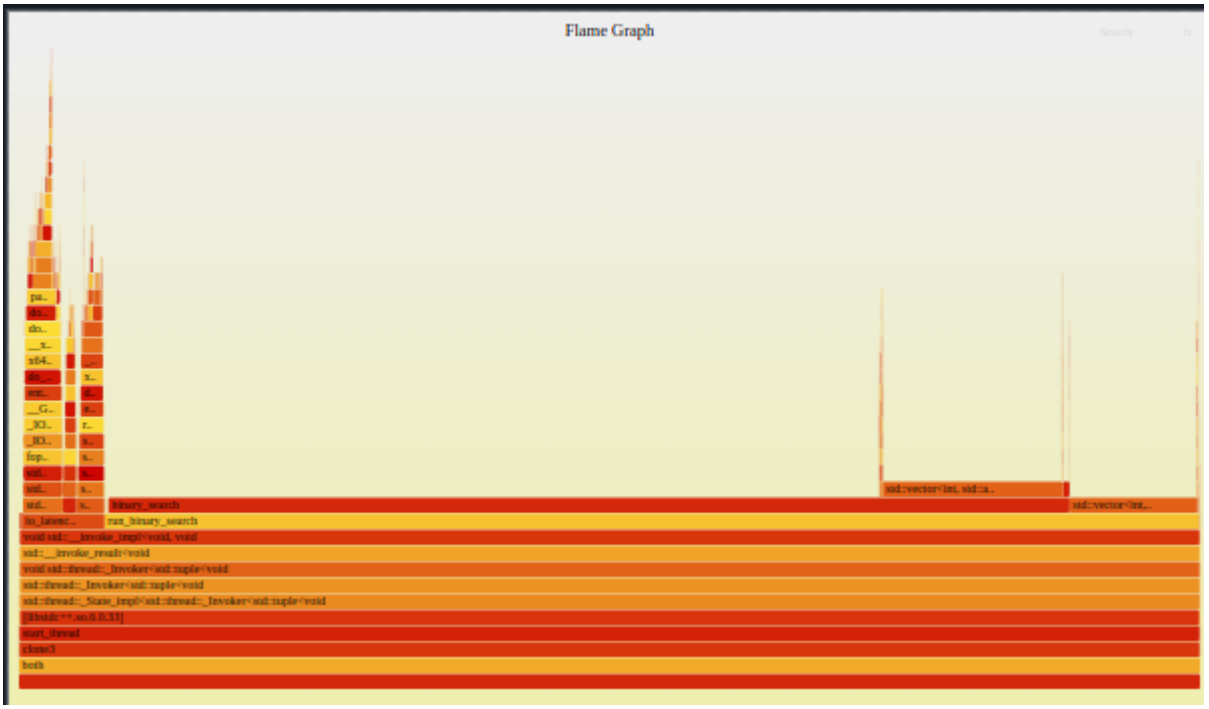
```
% time     seconds  usecs/call     calls    errors syscall
------ ----------- ----------- --------- --------- ----------------
 98.95    0.116226       58113         2           futex
  0.44    0.000514         514         1           execve
  0.40    0.000472          19        24           mmap
  0.09    0.000100          20         5           openat
  0.03    0.000039           7         5           fstat
  0.03    0.000030           7         4           read
  0.02    0.000026           5         5           close
  0.01    0.000015           7         2           pread64
  0.01    0.000013          13         1         1 access
  0.01    0.000008           2         3           brk
  0.00    0.000004           4         1           arch_prctl
  0.00    0.000004           4         1           set_robust_list
  0.00    0.000003           3         1           set_tid_address
  0.00    0.000003           3         1           rseq
  0.00    0.000000           0         8           mprotect
  0.00    0.000000           0         1           munmap
  0.00    0.000000           0         1           rt_sigaction
  0.00    0.000000           0         5           rt_sigprocmask
  0.00    0.000000           0         1           prlimit64
  0.00    0.000000           0         1           getrandom
  0.00    0.000000           0         2           clone3
------ ----------- ----------- --------- --------- ----------------
100.00    0.117457        1566        75         1 total
```

logs > single > both > perf.log

```

Performance counter stats for './../exec/both ./../shell.cpp 25000 25000000':

          1,812.33 msec task-clock                       #    1.075 CPUs utilized
                  90      context-switches                 #   49.660 /sec
                  22      cpu-migrations                   #   12.139 /sec
               1,116      page-faults                      #  615.781 /sec
       7,981,110,909      cycles                           #    4.404 GHz                         (42.82%)
         224,145,709      stalled-cycles-frontend          #    2.81% frontend cycles idle        (42.91%)
      30,264,850,342      instructions                     #    3.79  insn per cycle
                                                           #    0.01  stalled cycles per insn     (42.95%)
       3,526,930,781      branches                         #    1.946 G/sec                       (43.06%)
          12,050,179      branch-misses                    #    0.34% of all branches             (43.06%)
      10,003,024,374      L1-dcache-loads                  #    5.519 G/sec                       (43.06%)
           4,309,268      L1-dcache-load-misses            #    0.04% of all L1-dcache accesses   (43.02%)
     <not supported>      LLC-loads
     <not supported>      LLC-load-misses
         231,447,582      L1-icache-loads                  #  127.707 M/sec                       (43.06%)
           1,096,347      L1-icache-load-misses            #    0.47% of all L1-icache accesses   (42.98%)
           1,634,865      dTLB-loads                       #  902.078 K/sec                       (42.83%)
              29,844      dTLB-load-misses                 #    1.83% of all dTLB cache accesses  (42.94%)
               9,761      iTLB-loads                       #    5.386 K/sec                       (42.91%)
             397,294      iTLB-load-misses                 # 4070.22% of all iTLB cache accesses  (42.80%)
             468,978      L1-dcache-prefetches             #  258.770 K/sec                       (42.75%)
     <not supported>      L1-dcache-prefetch-misses

         1.686299812 seconds time elapsed

         1.700037000 seconds user
         0.112068000 seconds sys
```

logs > single > both > top.log

```
top - 07:14:31 up 2 days, 19:25,  1 user,  load average: 2.18, 2.62, 2.19
Tasks: 477 total,   2 running, 419 sleeping,  56 stopped,   0 zombie
%Cpu(s): 59.3 us, 39.4 sy,  0.8 ni,  0.0 id,  0.0 wa,  0.0 hi,  0.4 si,  0.0 st
MiB Mem :  15808.0 total,    952.9 free,   5414.2 used,   9965.8 buff/cache
MiB Swap:   4096.0 total,   4094.2 free,      1.8 used.  10393.8 avail Mem

    PID USER      PR  NI    VIRT    RES    SHR S  %CPU  %MEM     TIME+ COMMAND
 414552 root      20   0  157744   7296   3200 S  93.3   0.0   0:00.26 both
 414560 root      20   0  157744   7296   3200 S  93.3   0.0   0:00.27 both
 414565 root      20   0  157744   7424   3328 S  93.3   0.0   0:00.28 both
 414553 root      20   0  157744   7168   3072 S  86.7   0.0   0:00.27 both
 414554 root      20   0  157744   7296   3200 S  86.7   0.0   0:00.26 both
 414555 root      20   0  157744   7296   3200 S  86.7   0.0   0:00.26 both
 414556 root      20   0  157744   7296   3200 S  86.7   0.0   0:00.27 both
 414557 root      20   0  157744   7296   3200 S  86.7   0.0   0:00.26 both
 414559 root      20   0  157744   7296   3200 S  86.7   0.0   0:00.28 both
 414561 root      20   0  157744   7296   3200 S  86.7   0.0   0:00.26 both
 414563 root      20   0  157744   7296   3200 S  86.7   0.0   0:00.15 both
 414564 root      20   0  157744   7296   3200 S  86.7   0.0   0:00.26 both
 414567 root      20   0  157744   7424   3328 S  86.7   0.0   0:00.25 both
 414558 root      20   0  157744   7424   3328 S  80.0   0.0   0:00.24 both
 414566 root      20   0  157744   7424   3328 S  80.0   0.0   0:00.23 both
 414562 root      20   0  157744   7296   3200 S  73.3   0.0   0:00.22 both
```



50000000 | 50000 итераций

logs > double > both > ltrace.log

```
% time     seconds  usecs/call     calls      function
------ ----------- ----------- --------- --------------------
100.00   69.538803    34769401         2 _ZNSt6thread4joinEv
  0.00    0.000735         367         2 _ZNSt6thread15_M_start_threadESt10unique_ptrINS_6_StateESt14default_deleteIS1_EEPFvvE
  0.00    0.000245         122         2 atoi
  0.00    0.000191          95         2 _Znwm
------ ----------- ----------- --------- --------------------
100.00   69.539974                     8 total
```

logs > double > both > strace.log

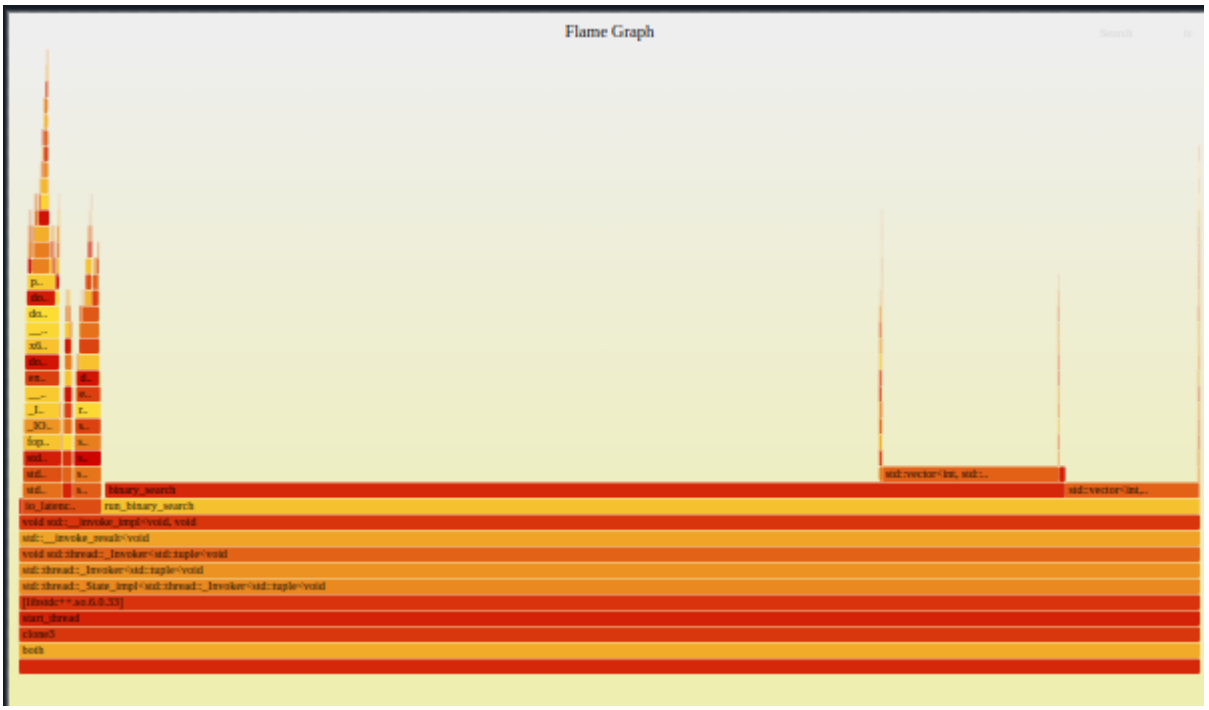
```
% time     seconds  usecs/call     calls    errors syscall
------ ----------- ----------- --------- --------- ----------------
 99.96    0.204150      102075         2           futex
  0.02    0.000050          25         2           clone3
  0.01    0.000012           1         8           mprotect
  0.00    0.000009           1         5           rt_sigprocmask
  0.00    0.000007           0        24           mmap
  0.00    0.000000           0         4           read
  0.00    0.000000           0         5           close
  0.00    0.000000           0         5           fstat
  0.00    0.000000           0         1           munmap
  0.00    0.000000           0         3           brk
  0.00    0.000000           0         1           rt_sigaction
  0.00    0.000000           0         2           pread64
  0.00    0.000000           0         1         1 access
  0.00    0.000000           0         1           execve
  0.00    0.000000           0         1           arch_prctl
  0.00    0.000000           0         1           set_tid_address
  0.00    0.000000           0         5           openat
  0.00    0.000000           0         1           set_robust_list
  0.00    0.000000           0         1           prlimit64
  0.00    0.000000           0         1           getrandom
  0.00    0.000000           0         1           rseq
------ ----------- ----------- --------- --------- ----------------
100.00    0.204228        2723        75         1 total
```

logs > double > both > perf.log

```
Performance counter stats for './../exec/both ./../shell.cpp 50000 50000000':

          3,575.54 msec task-clock                       #    1.073 CPUs utilized
                77      context-switches                 #   21.535 /sec
                 9      cpu-migrations                   #    2.517 /sec
             1,116      page-faults                      #  312.120 /sec
    15,934,073,396      cycles                           #    4.456 GHz                         (42.73%)
       444,064,789      stalled-cycles-frontend          #    2.79% frontend cycles idle        (42.71%)
    60,642,265,575      instructions                     #    3.81  insn per cycle
                                                   #    0.01  stalled cycles per insn     (42.73%)
     7,046,667,787      branches                         #    1.971 G/sec                       (42.93%)
        22,591,400      branch-misses                    #    0.32% of all branches             (42.96%)
    19,976,045,884      L1-dcache-loads                  #    5.587 G/sec                       (43.00%)
         6,884,785      L1-dcache-load-misses            #    0.03% of all L1-dcache accesses   (43.05%)
   <not supported>      LLC-loads
   <not supported>      LLC-load-misses
       444,321,857      L1-icache-loads                  #  124.267 M/sec                       (43.05%)
         2,441,486      L1-icache-load-misses            #    0.55% of all L1-icache accesses   (43.03%)
         3,269,960      dTLB-loads                       #  914.535 K/sec                       (43.01%)
            44,512      dTLB-load-misses                 #    1.36% of all dTLB cache accesses  (42.97%)
            33,113      iTLB-loads                       #    9.261 K/sec                       (42.89%)
           818,732      iTLB-load-misses                 # 2472.54% of all iTLB cache accesses  (42.81%)
           818,150      L1-dcache-prefetches             #  228.818 K/sec                       (42.78%)
   <not supported>      L1-dcache-prefetch-misses

       3.332182966 seconds time elapsed

       3.362111000 seconds user
       0.213007000 seconds sys
```

logs > double > both > top.log

```
top - 07:18:17 up 2 days, 19:29,  1 user,  load average: 1.88, 2.45, 2.23
Tasks: 483 total,   2 running, 425 sleeping,  56 stopped,   0 zombie
%Cpu(s): 57.8 us, 42.2 sy,  0.0 ni,  0.0 id,  0.0 wa,  0.0 hi,  0.0 si,  0.0 st
MiB Mem :  15808.0 total,    855.1 free,   5302.0 used,  10146.2 buff/cache
MiB Swap:   4096.0 total,   4094.2 free,      1.8 used.  10505.9 avail Mem

    PID USER      PR  NI    VIRT    RES    SHR S  %CPU  %MEM     TIME+ COMMAND
 416744 root      20   0  157744   7424   3328 S 100.0   0.0   0:00.31 both
 416738 root      20   0  157744   7424   3328 S  93.8   0.0   0:00.31 both
 416741 root      20   0  157744   7424   3328 S  93.8   0.0   0:00.31 both
 416742 root      20   0  157744   7424   3328 S  93.8   0.0   0:00.30 both
 416763 root      20   0  157744   7424   3328 S  93.8   0.0   0:00.24 both
 416736 root      20   0  157744   7424   3328 S  87.5   0.0   0:00.29 both
 416737 root      20   0  157744   7296   3200 S  87.5   0.0   0:00.29 both
 416739 root      20   0  157744   7424   3328 S  87.5   0.0   0:00.29 both
 416740 root      20   0  157744   7424   3328 S  87.5   0.0   0:00.27 both
 416743 root      20   0  157744   7424   3328 S  87.5   0.0   0:00.29 both
 416745 root      20   0  157744   7424   3328 S  87.5   0.0   0:00.28 both
 416746 root      20   0  157744   7424   3328 S  87.5   0.0   0:00.26 both
 416748 root      20   0  157744   7424   3328 S  87.5   0.0   0:00.29 both
 416749 root      20   0  157744   7424   3328 S  87.5   0.0   0:00.28 both
 416747 root      20   0  157744   7424   3328 S  81.2   0.0   0:00.24 both
 416758 root      20   0  157744   7424   3328 S  75.0   0.0   0:00.25 both
```



75000000 | 75000 итераций

logs > triple > both > ltrace.log

```
% time     seconds  usecs/call     calls      function
------ ----------- ----------- --------- --------------------
100.00  102.631205    51315602         2 _ZNSt6thread4joinEv
  0.00    0.000893         446         2 _ZNSt6thread15_M_start_threadESt10unique_ptrINS_6_StateESt14default_deleteIS1_EEPFvvE
  0.00    0.000244         122         2 atoi
  0.00    0.000178          89         2 _Znwm
------ ----------- ----------- --------- --------------------
100.00  102.632520                     8 total
```

logs > triple > both > strace.log

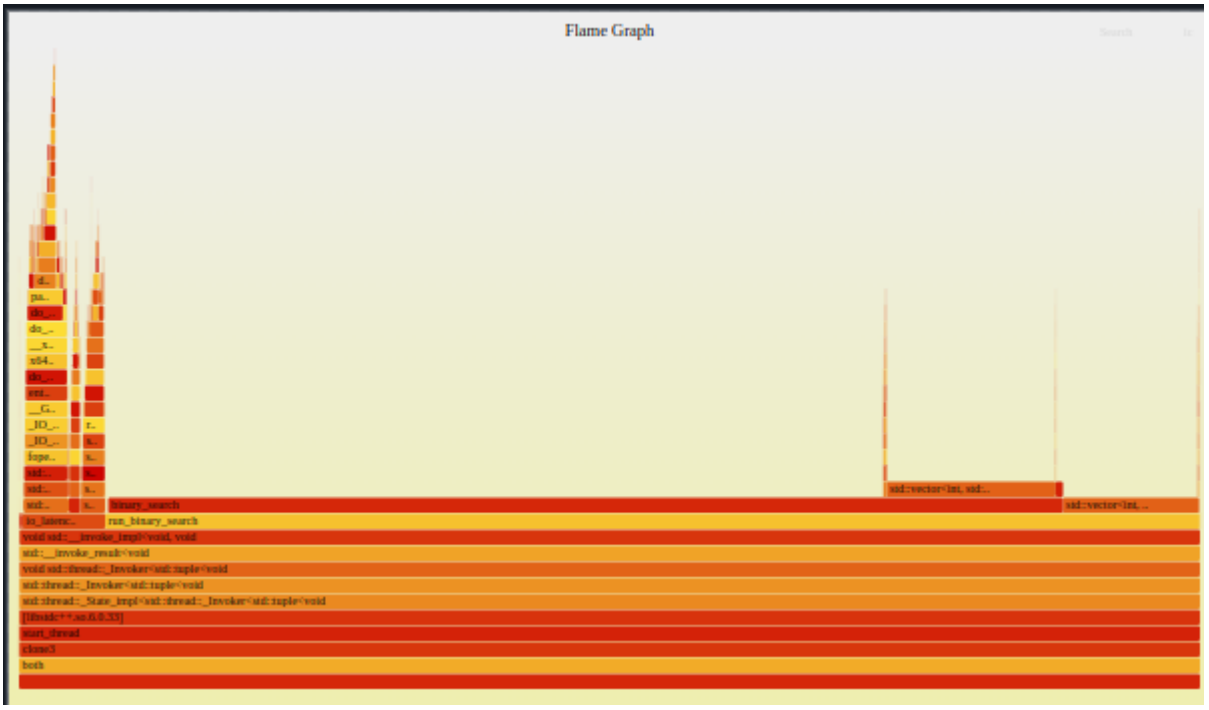
```
% time     seconds  usecs/call     calls    errors syscall
------ ----------- ----------- --------- --------- ----------------
100.00    0.295871      147935         2           futex
  0.00    0.000000           0         4           read
  0.00    0.000000           0         5           close
  0.00    0.000000           0         5           fstat
  0.00    0.000000           0        24           mmap
  0.00    0.000000           0         8           mprotect
  0.00    0.000000           0         1           munmap
  0.00    0.000000           0         3           brk
  0.00    0.000000           0         1           rt_sigaction
  0.00    0.000000           0         5           rt_sigprocmask
  0.00    0.000000           0         2           pread64
  0.00    0.000000           0         1         1 access
  0.00    0.000000           0         1           execve
  0.00    0.000000           0         1           arch_prctl
  0.00    0.000000           0         1           set_tid_address
  0.00    0.000000           0         5           openat
  0.00    0.000000           0         1           set_robust_list
  0.00    0.000000           0         1           prlimit64
  0.00    0.000000           0         1           getrandom
  0.00    0.000000           0         1           rseq
  0.00    0.000000           0         2           clone3
------ ----------- ----------- --------- --------- ----------------
100.00    0.295871        3944        75         1 total
```

logs > triple > both > perf.log

```

Performance counter stats for './../exec/both ./../shell.cpp 75000 75000000':

          5,323.98 msec task-clock                       #    1.074 CPUs utilized
                54      context-switches                 #   10.143 /sec
                30      cpu-migrations                   #    5.635 /sec
             1,114      page-faults                      #  209.242 /sec
    23,873,517,202      cycles                           #    4.484 GHz                         (42.84%)
       688,973,656      stalled-cycles-frontend          #    2.89% frontend cycles idle        (42.85%)
    90,733,020,937      instructions                     #    3.80  insn per cycle
                                                         #    0.01  stalled cycles per insn     (42.87%)
    10,586,156,093      branches                         #    1.988 G/sec                       (42.90%)
        34,630,199      branch-misses                    #    0.33% of all branches             (42.91%)
    30,006,011,935      L1-dcache-loads                  #    5.636 G/sec                       (42.93%)
        10,852,292      L1-dcache-load-misses            #    0.04% of all L1-dcache accesses   (42.98%)
   <not supported>      LLC-loads
   <not supported>      LLC-load-misses
       662,641,847      L1-icache-loads                  #  124.464 M/sec                       (42.95%)
         4,035,688      L1-icache-load-misses            #    0.61% of all L1-icache accesses   (42.92%)
         4,501,130      dTLB-loads                       #  845.444 K/sec                       (42.87%)
            23,579      dTLB-load-misses                 #    0.52% of all dTLB cache accesses  (42.85%)
            18,091      iTLB-loads                       #    3.398 K/sec                       (42.83%)
         1,206,167      iTLB-load-misses                 # 6667.22% of all iTLB cache accesses  (42.87%)
         1,226,607      L1-dcache-prefetches             #  230.393 K/sec                       (42.85%)
   <not supported>      L1-dcache-prefetch-misses

       4.956071927 seconds time elapsed

       5.014058000 seconds user
       0.309880000 seconds sys
```

logs > triple > both > top.log

```
top - 07:24:03 up 2 days, 19:35,  1 user,  load average: 1.87, 2.22, 2.24
Tasks: 474 total,   1 running, 417 sleeping,  56 stopped,   0 zombie
%Cpu(s): 55.9 us, 44.1 sy,  0.0 ni,  0.0 id,  0.0 wa,  0.0 hi,  0.0 si,  0.0 st
MiB Mem :  15808.0 total,    858.4 free,   5294.8 used,  10139.4 buff/cache
MiB Swap:   4096.0 total,   4094.2 free,      1.8 used.  10513.2 avail Mem

    PID USER      PR  NI    VIRT    RES    SHR S  %CPU  %MEM     TIME+ COMMAND
 418725 root      20   0  157744   7296   3200 S 100.0   0.0   0:00.28 both
 418726 root      20   0  157744   7424   3328 S 100.0   0.0   0:00.29 both
 418729 root      20   0  157744   7424   3328 S 100.0   0.0   0:00.29 both
 418731 root      20   0  157744   7296   3200 S 100.0   0.0   0:00.29 both
 418734 root      20   0  157744   7424   3328 S 100.0   0.0   0:00.29 both
 418736 root      20   0  157744   7424   3328 S 100.0   0.0   0:00.29 both
 418724 root      20   0  157744   7296   3200 S  93.3   0.0   0:00.27 both
 418732 root      20   0  157744   7424   3328 S  93.3   0.0   0:00.29 both
 418743 root      20   0  157744   7424   3328 S  93.3   0.0   0:00.28 both
 418744 root      20   0  157744   7424   3328 S  93.3   0.0   0:00.28 both
 418745 root      20   0  157744   7424   3328 S  93.3   0.0   0:00.27 both
 418727 root      20   0  157744   7424   3328 S  86.7   0.0   0:00.25 both
 418730 root      20   0  157744   7296   3200 S  86.7   0.0   0:00.22 both
 418735 root      20   0  157744   7424   3328 S  86.7   0.0   0:00.26 both
 418728 root      20   0  157744   7296   3200 S  80.0   0.0   0:00.24 both
 418733 root      20   0  157744   7424   3328 S  80.0   0.0   0:00.25 both
```



100000000 | 100000 итераций

logs > quad > both > ltrace.log

```
% time     seconds  usecs/call     calls      function
------ ----------- ----------- --------- --------------------
100.00  137.797744    68898872         2 _ZNSt6thread4joinEv
  0.00    0.000669         334         2 _ZNSt6thread15_M_start_threadESt10unique_ptrINS_6_StateESt14default_deleteIS1_EEPFvvE
  0.00    0.000331         165         2 atoi
  0.00    0.000199          99         2 _Znwm
------ ----------- ----------- --------- --------------------
100.00  137.798943                     8 total
```

logs > quad > both > strace.log

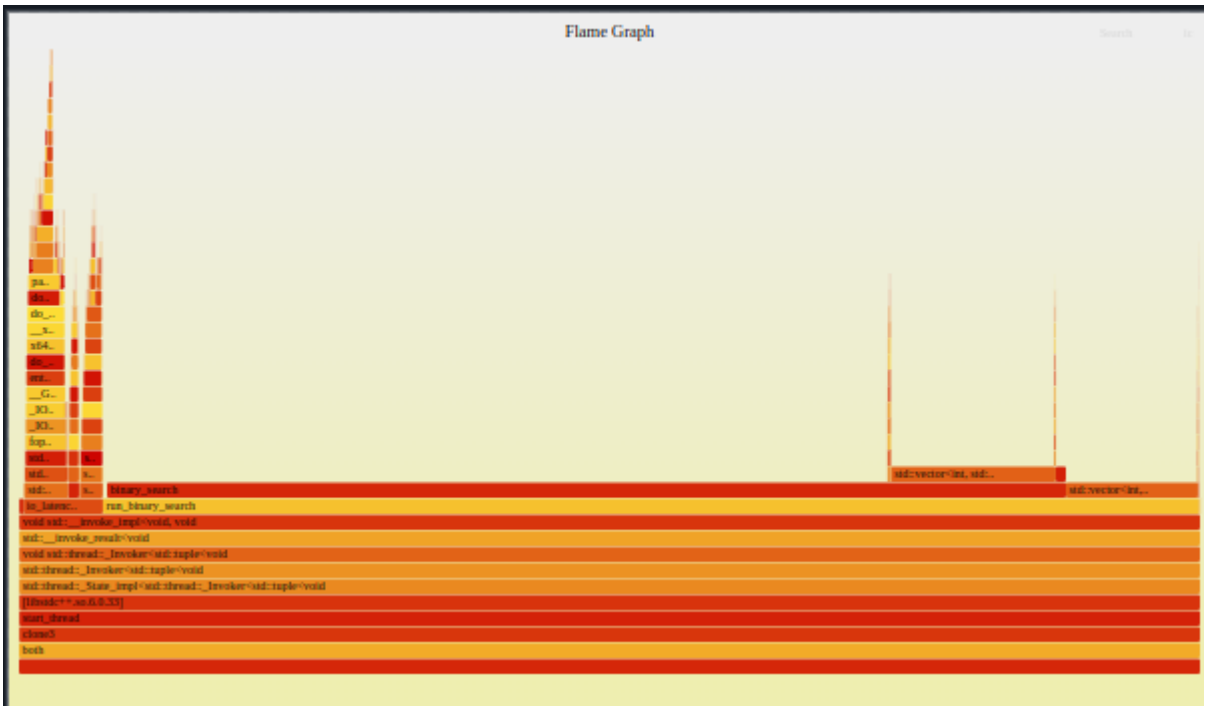
```
% time     seconds  usecs/call     calls    errors syscall
------ ----------- ----------- --------- --------- ----------------
 99.82    0.406171      203085         2           futex
  0.09    0.000355          14        24           mmap
  0.02    0.000069           8         8           mprotect
  0.02    0.000063          12         5           openat
  0.01    0.000050          25         2           clone3
  0.01    0.000040           8         5           fstat
  0.01    0.000027           6         4           read
  0.01    0.000027           9         3           brk
  0.01    0.000026           5         5           close
  0.00    0.000020           4         5           rt_sigprocmask
  0.00    0.000018           9         2           pread64
  0.00    0.000016          16         1           munmap
  0.00    0.000009           9         1         1 access
  0.00    0.000005           5         1           prlimit64
  0.00    0.000004           4         1           rt_sigaction
  0.00    0.000004           4         1           getrandom
  0.00    0.000003           3         1           arch_prctl
  0.00    0.000003           3         1           set_robust_list
  0.00    0.000003           3         1           rseq
  0.00    0.000002           2         1           set_tid_address
  0.00    0.000000           0         1           execve
------ ----------- ----------- --------- --------- ----------------
100.00    0.406915        5425        75         1 total
```

logs > quad > both > perf.log

```

Performance counter stats for './../exec/both ./../shell.cpp 100000 100000000':

          7,114.44 msec task-clock                       #    1.074 CPUs utilized
                53      context-switches                 #    7.450 /sec
                17      cpu-migrations                   #    2.390 /sec
             1,115      page-faults                      #  156.724 /sec
    31,855,875,633      cycles                           #    4.478 GHz                         (42.84%)
       922,420,568      stalled-cycles-frontend          #    2.90% frontend cycles idle        (42.84%)
   121,001,868,774      instructions                     #    3.80  insn per cycle
                                                  #    0.01  stalled cycles per insn     (42.85%)
    14,130,899,793      branches                         #    1.986 G/sec                       (42.86%)
        46,595,522      branch-misses                    #    0.33% of all branches             (42.88%)
    40,019,813,931      L1-dcache-loads                  #    5.625 G/sec                       (42.93%)
        13,384,802      L1-dcache-load-misses            #    0.03% of all L1-dcache accesses   (42.95%)
   <not supported>      LLC-loads
   <not supported>      LLC-load-misses
       900,997,472      L1-icache-loads                  #  126.643 M/sec                       (42.94%)
         4,727,931      L1-icache-load-misses            #    0.52% of all L1-icache accesses   (42.91%)
         6,429,667      dTLB-loads                       #  903.749 K/sec                       (42.89%)
            19,466      dTLB-load-misses                 #    0.30% of all dTLB cache accesses  (42.87%)
            27,811      iTLB-loads                       #    3.909 K/sec                       (42.86%)
         1,602,784      iTLB-load-misses                 # 5763.13% of all iTLB cache accesses  (42.83%)
         1,664,209      L1-dcache-prefetches             #  233.920 K/sec                       (42.85%)
   <not supported>      L1-dcache-prefetch-misses

       6.621795057 seconds time elapsed

       6.711380000 seconds user
       0.402962000 seconds sys
```

logs > quad > both > top.log

```
1   top - 07:31:53 up 2 days, 19:43,  1 user,  load average: 1.79, 2.72, 2.65
2   Tasks: 475 total,   1 running, 418 sleeping,  56 stopped,   0 zombie
3   %Cpu(s): 56.9 us, 43.1 sy,  0.0 ni,  0.0 id,  0.0 wa,  0.0 hi,  0.0 si,  0.0 st
4   MiB Mem :  15808.0 total,    849.0 free,   5390.8 used,  10062.3 buff/cache
5   MiB Swap:   4096.0 total,   4094.2 free,      1.8 used.  10417.2 avail Mem
6
7     PID USER      PR  NI    VIRT    RES    SHR S  %CPU  %MEM     TIME+ COMMAND
8  421404 root      20   0  157744   7296   3200 S 106.7   0.0   0:00.29 both
9  421391 root      20   0  157744   7296   3200 S 100.0   0.0   0:00.29 both
10 421393 root      20   0  157744   7296   3200 S 100.0   0.0   0:00.30 both
11 421398 root      20   0  157744   7424   3328 S 100.0   0.0   0:00.30 both
12 421399 root      20   0  157744   7424   3328 S 100.0   0.0   0:00.28 both
13 421401 root      20   0  157744   7424   3328 S 100.0   0.0   0:00.29 both
14 421402 root      20   0  157744   7424   3328 S 100.0   0.0   0:00.29 both
15 421410 root      20   0  157744   7296   3200 S 100.0   0.0   0:00.29 both
16 421390 root      20   0  157744   7296   3200 S  93.3   0.0   0:00.27 both
17 421392 root      20   0  157744   7296   3200 S  93.3   0.0   0:00.29 both
18 421394 root      20   0  157744   7296   3200 S  93.3   0.0   0:00.28 both
19 421395 root      20   0  157744   7424   3328 S  93.3   0.0   0:00.29 both
20 421396 root      20   0  157744   7424   3328 S  93.3   0.0   0:00.29 both
21 421400 root      20   0  157744   7424   3328 S  93.3   0.0   0:00.27 both
22 421403 root      20   0  157744   7424   3328 S  93.3   0.0   0:00.28 both
23 421397 root      20   0  157744   7424   3328 S  86.7   0.0   0:00.26 both
```



---

both (optimized)

25000000 | 25000 итераций

logs > single > both_opt > ltrace.log

```
% time     seconds  usecs/call     calls      function
------ ----------- ----------- --------- --------------------
100.00   35.315499    17657749         2 _ZNSt6thread4joinEv
  0.00    0.001100         550         2 _ZNSt6thread15_M_start_threadESt10unique_ptrINS_6_StateESt14default_deleteIS1_EEPFvvE
  0.00    0.000209         104         2 _Znwm
  0.00    0.000132          66         2 __isoc23_strtol
------ ----------- ----------- --------- --------------------
100.00   35.316940                     8 total
```

logs > single > both_opt > strace.log

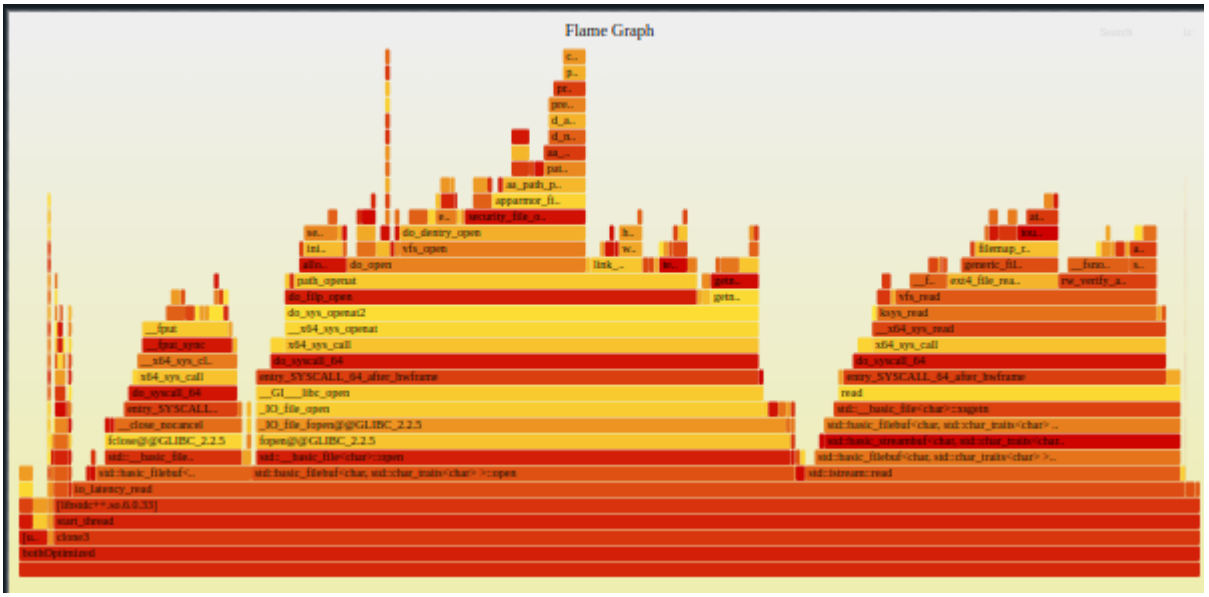
```
% time     seconds  usecs/call     calls    errors syscall
------ ----------- ----------- --------- --------- ----------------
100.00    0.101305       33768         3           futex
  0.00    0.000000           0         4           read
  0.00    0.000000           0         5           close
  0.00    0.000000           0         5           fstat
  0.00    0.000000           0        24           mmap
  0.00    0.000000           0         8           mprotect
  0.00    0.000000           0         1           munmap
  0.00    0.000000           0         3           brk
  0.00    0.000000           0         1           rt_sigaction
  0.00    0.000000           0         5           rt_sigprocmask
  0.00    0.000000           0         2           pread64
  0.00    0.000000           0         1         1 access
  0.00    0.000000           0         1           execve
  0.00    0.000000           0         1           arch_prctl
  0.00    0.000000           0         1           set_tid_address
  0.00    0.000000           0         5           openat
  0.00    0.000000           0         1           set_robust_list
  0.00    0.000000           0         1           prlimit64
  0.00    0.000000           0         1           getrandom
  0.00    0.000000           0         1           rseq
  0.00    0.000000           0         2           clone3
------ ----------- ----------- --------- --------- ----------------
100.00    0.101305        1332        76         1 total
```

logs > single > both_opt > perf.log

```
Performance counter stats for './../exec/bothOptimized ./../shell.cpp 25000 25000000':

            127.46 msec task-clock                       #    1.008 CPUs utilized
                26      context-switches                 #  203.992 /sec
                16      cpu-migrations                   #  125.534 /sec
             1,117      page-faults                      #    8.764 K/sec
       555,049,039      cycles                           #    4.355 GHz                         (42.49%)
       191,783,031      stalled-cycles-frontend          #   34.55% frontend cycles idle        (42.77%)
       483,069,317      instructions                     #    0.87  insn per cycle
                                                   #    0.40  stalled cycles per insn     (43.36%)
       101,988,241      branches                         #  800.184 M/sec                       (43.75%)
        10,570,396      branch-misses                    #   10.36% of all branches             (43.72%)
       196,337,271      L1-dcache-loads                  #    1.540 G/sec                        (44.05%)
         2,914,464      L1-dcache-load-misses            #    1.48% of all L1-dcache accesses   (46.58%)
   <not supported>      LLC-loads
   <not supported>      LLC-load-misses
       201,033,370      L1-icache-loads                  #    1.577 G/sec                        (45.79%)
         1,243,407      L1-icache-load-misses            #    0.62% of all L1-icache accesses   (44.54%)
         1,594,538      dTLB-loads                       #   12.511 M/sec                        (43.79%)
            10,670      dTLB-load-misses                 #    0.67% of all dTLB cache accesses  (43.92%)
             6,187      iTLB-loads                       #   48.542 K/sec                        (43.55%)
           412,723      iTLB-load-misses                 # 6670.81% of all iTLB cache accesses  (43.17%)
           321,813      L1-dcache-prefetches             #    2.525 M/sec                        (42.70%)
   <not supported>      L1-dcache-prefetch-misses

       0.126417971 seconds time elapsed

       0.022628000 seconds user
       0.104290000 seconds sys
```

logs > single > both_opt > top.log

```
top - 07:15:19 up 2 days, 19:26,  1 user,  load average: 2.47, 2.70, 2.24
Tasks: 454 total,   1 running, 397 sleeping,  56 stopped,   0 zombie
%Cpu(s): 17.8 us, 81.2 sy,  1.0 ni,  0.0 id,  0.0 wa,  0.0 hi,  0.0 si,  0.0 st
MiB Mem :  15808.0 total,   1163.2 free,   5202.2 used,   9934.1 buff/cache
MiB Swap:   4096.0 total,   4094.2 free,      1.8 used.  10605.8 avail Mem

    PID USER      PR  NI    VIRT    RES    SHR S  %CPU  %MEM     TIME+ COMMAND
 303857 junayd    20   0 1158.0g 457528 161220 S  16.7   2.8  21:52.19 chrome
   3221 junayd    20   0 4788724 663348 139416 S   8.3   4.1  90:11.29 gnome-s+
 361989 junayd    20   0   33.0g 316400 179392 S   8.3   2.0   6:18.42 chrome
 414879 root      20   0   23196   5376   3328 R   8.3   0.0   0:00.02 top
      1 root      20   0   23640  14328   9080 S   0.0   0.1   0:17.00 systemd
      2 root      20   0       0      0      0 S   0.0   0.0   0:00.16 kthreadd
      3 root      20   0       0      0      0 S   0.0   0.0   0:00.00 pool_wo+
      4 root       0 -20       0      0      0 I   0.0   0.0   0:00.00 kworker+
      5 root       0 -20       0      0      0 I   0.0   0.0   0:00.00 kworker+
      6 root       0 -20       0      0      0 I   0.0   0.0   0:00.00 kworker+
      7 root       0 -20       0      0      0 I   0.0   0.0   0:00.00 kworker+
     10 root       0 -20       0      0      0 I   0.0   0.0   0:00.00 kworker+
     12 root       0 -20       0      0      0 I   0.0   0.0   0:00.00 kworker+
     13 root      20   0       0      0      0 I   0.0   0.0   0:00.00 rcu_tas+
     14 root      20   0       0      0      0 I   0.0   0.0   0:00.00 rcu_tas+
     15 root      20   0       0      0      0 I   0.0   0.0   0:00.00 rcu_tas+
     16 root      20   0       0      0      0 S   0.0   0.0   0:02.23 ksoftir+
     17 root      20   0       0      0      0 I   0.0   0.0   1:16.34 rcu_pre+
     18 root      rt   0       0      0      0 S   0.0   0.0   0:33.42 migrati+
     19 root     -51   0       0      0      0 S   0.0   0.0   0:00.00 idle_in+
     20 root      20   0       0      0      0 S   0.0   0.0   0:00.00 cpuhp/0
```



50000000 | 50000 итераций

logs > double > both_opt > ltrace.log

```
% time     seconds  usecs/call     calls      function
------ ----------- ----------- --------- --------------------
100.00   73.204772    36602386         2 _ZNSt6thread4joinEv
  0.00    0.000711         355         2 _ZNSt6thread15_M_start_threadESt10unique_ptrINS_6_StateESt14default_deleteIS1_EEPFvvE
  0.00    0.000144          72         2 _Znwm
  0.00    0.000138          69         2 __isoc23_strtol
------ ----------- ----------- --------- --------------------
100.00   73.205765                     8 total
```

logs > double > both_opt > strace.log

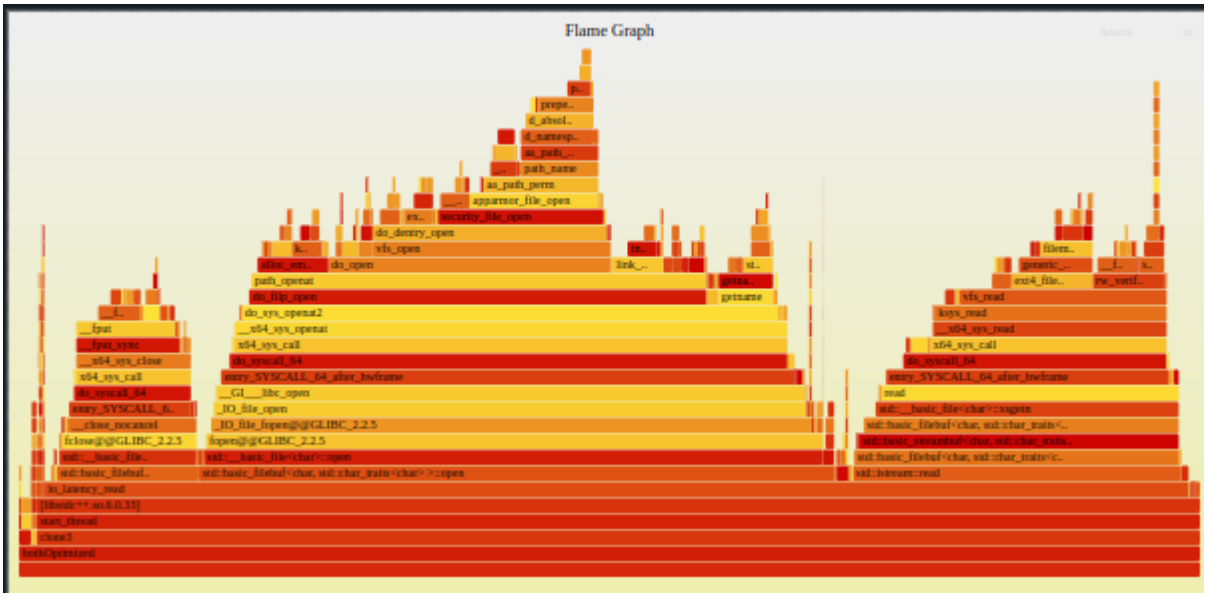
% time	seconds	usecs/call	calls	errors	syscall
99.36	0.205009	68336	3		futex
0.23	0.000484	20	24		mmap
0.21	0.000441	441	1		execve
0.05	0.000107	13	8		mprotect
0.04	0.000088	17	5		openat
0.02	0.000048	9	5		fstat
0.02	0.000035	8	4		read
0.02	0.000034	6	5		close
0.01	0.000019	9	2		pread64
0.01	0.000017	8	2		clone3
0.01	0.000011	3	3		brk
0.01	0.000011	11	1	1	access
0.00	0.000007	1	5		rt_sigprocmask
0.00	0.000005	5	1		arch_prctl
0.00	0.000004	4	1		set_tid_address
0.00	0.000004	4	1		set_robust_list
0.00	0.000003	3	1		rseq
0.00	0.000000	0	1		munmap
0.00	0.000000	0	1		rt_sigaction
0.00	0.000000	0	1		prlimit64
0.00	0.000000	0	1		getrandom
100.00	0.206327	2714	76	1	total

logs > double > both_opt > perf.log

```
Performance counter stats for './../exec/bothOptimized ./../shell.cpp 50000 50000000':

            256.42 msec task-clock                       #    1.007 CPUs utilized
                51      context-switches                 #  198.895 /sec
                17      cpu-migrations                   #   66.298 /sec
             1,116      page-faults                      #    4.352 K/sec
     1,105,780,925      cycles                           #    4.312 GHz                         (42.98%)
       386,365,647      stalled-cycles-frontend          #   34.94% frontend cycles idle        (43.27%)
       971,581,342      instructions                     #    0.88  insn per cycle
                                                   #    0.40  stalled cycles per insn     (43.63%)
       206,683,659      branches                         #  806.048 M/sec                       (43.83%)
        21,511,099      branch-misses                    #   10.41% of all branches             (44.05%)
       395,560,787      L1-dcache-loads                  #    1.543 G/sec                        (44.09%)
         7,425,819      L1-dcache-load-misses            #    1.88% of all L1-dcache accesses   (43.78%)
   <not supported>      LLC-loads
   <not supported>      LLC-load-misses
       407,433,655      L1-icache-loads                  #    1.589 G/sec                        (43.37%)
         2,236,447      L1-icache-load-misses            #    0.55% of all L1-icache accesses   (43.87%)
         3,266,633      dTLB-loads                       #   12.740 M/sec                        (43.31%)
            10,525      dTLB-load-misses                 #    0.32% of all dTLB cache accesses  (42.73%)
            32,173      iTLB-loads                       #  125.472 K/sec                        (42.59%)
           806,974      iTLB-load-misses                 # 2508.23% of all iTLB cache accesses  (43.03%)
           736,217      L1-dcache-prefetches             #    2.871 M/sec                        (42.88%)
   <not supported>      L1-dcache-prefetch-misses

y-projects/os-lab-1/logs/single/both 13 seconds time elapsed

       0.048445000 seconds user
       0.207621000 seconds sys
```

logs > double > both_opt > top.log

```
top - 07:19:49 up 2 days, 19:31,  1 user,  load average: 2.28, 2.61, 2.33
Tasks: 480 total,   4 running, 420 sleeping,  56 stopped,   0 zombie
%Cpu(s): 18.8 us, 80.8 sy,  0.5 ni,  0.0 id,  0.0 wa,  0.0 hi,  0.0 si,  0.0 st
MiB Mem :  15808.0 total,    851.3 free,   5304.7 used,  10145.0 buff/cache
MiB Swap:   4096.0 total,   4094.2 free,      1.8 used.  10503.3 avail Mem

    PID USER      PR  NI    VIRT    RES    SHR S  %CPU  %MEM     TIME+ COMMAND
 417277 root      20   0  153824   3564   3328 S 100.0   0.0   0:00.25 bothOpt+
 417278 root      20   0  153824   3560   3328 S 100.0   0.0   0:00.25 bothOpt+
 417284 root      20   0  153824   3688   3456 S 100.0   0.0   0:00.25 bothOpt+
 417290 root      20   0  153824   3560   3328 S 100.0   0.0   0:00.23 bothOpt+
 417274 root      20   0  153824   3560   3328 S  92.3   0.0   0:00.25 bothOpt+
 417275 root      20   0  153824   3692   3456 S  92.3   0.0   0:00.24 bothOpt+
 417276 root      20   0  153824   3692   3456 S  92.3   0.0   0:00.25 bothOpt+
 417279 root      20   0  153824   3688   3456 S  92.3   0.0   0:00.24 bothOpt+
 417280 root      20   0  153824   3688   3456 S  92.3   0.0   0:00.23 bothOpt+
 417282 root      20   0  153824   3688   3456 S  92.3   0.0   0:00.22 bothOpt+
 417283 root      20   0  153824   3688   3456 S  92.3   0.0   0:00.24 bothOpt+
 417296 root      20   0  153824   3680   3456 S  92.3   0.0   0:00.22 bothOpt+
 417281 root      20   0  153824   3688   3456 S  84.6   0.0   0:00.23 bothOpt+
 417293 root      20   0  153824   3688   3456 S  84.6   0.0   0:00.22 bothOpt+
 417295 root      20   0  153824   3688   3456 S  84.6   0.0   0:00.20 bothOpt+
 417273 root      20   0  153824   3564   3328 S  76.9   0.0   0:00.21 bothOpt+
```



75000000 | 75000 итераций

logs > triple > both_opt > ltrace.log

```
% time     seconds  usecs/call     calls      function
------ ----------- ----------- --------- --------------------
100.00  111.315626    55657813         2 _ZNSt6thread4joinEv
  0.00    0.000834         417         2 _ZNSt6thread15_M_start_threadESt10unique_ptrINS_6_StateESt14default_deleteIS1_EEPFvvE
  0.00    0.000242         121         2 __isoc23_strtol
  0.00    0.000198          99         2 _Znwm
------ ----------- ----------- --------- --------------------
100.00  111.316900                     8 total
```

logs > triple > both_opt > strace.log

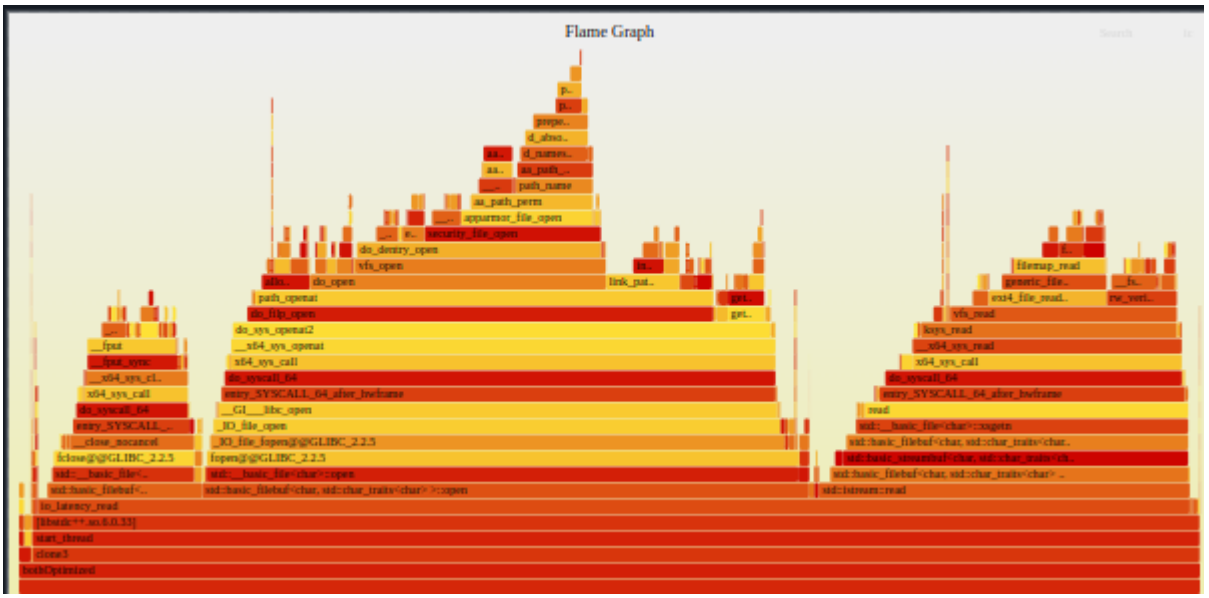
```
% time     seconds  usecs/call     calls    errors syscall
------ ----------- ----------- --------- --------- ----------------
 99.99    0.307105      102368         3           futex
  0.01    0.000016           8         2           clone3
  0.00    0.000007           0         8           mprotect
  0.00    0.000006           1         5           rt_sigprocmask
  0.00    0.000000           0         4           read
  0.00    0.000000           0         5           close
  0.00    0.000000           0         5           fstat
  0.00    0.000000           0        24           mmap
  0.00    0.000000           0         1           munmap
  0.00    0.000000           0         3           brk
  0.00    0.000000           0         1           rt_sigaction
  0.00    0.000000           0         2           pread64
  0.00    0.000000           0         1         1 access
  0.00    0.000000           0         1           execve
  0.00    0.000000           0         1           arch_prctl
  0.00    0.000000           0         1           set_tid_address
  0.00    0.000000           0         5           openat
  0.00    0.000000           0         1           set_robust_list
  0.00    0.000000           0         1           prlimit64
  0.00    0.000000           0         1           getrandom
  0.00    0.000000           0         1           rseq
------ ----------- ----------- --------- --------- ----------------
100.00    0.307134        4041        76         1 total
```

logs > triple > both_opt > perf.log

```
Performance counter stats for './../exec/bothOptimized ./../shell.cpp 75000 75000000':

            367.58 msec task-clock                       #    1.002 CPUs utilized
                37      context-switches                 #  100.657 /sec
                10      cpu-migrations                   #   27.205 /sec
             1,118      page-faults                      #    3.041 K/sec
     1,639,271,110      cycles                           #    4.460 GHz                         (42.68%)
       569,888,001      stalled-cycles-frontend          #   34.76% frontend cycles idle        (42.89%)
     1,449,937,672      instructions                     #    0.88  insn per cycle
                                                   #    0.39  stalled cycles per insn     (43.03%)
       306,135,096      branches                         #  832.832 M/sec                       (43.20%)
        31,784,601      branch-misses                    #   10.38% of all branches             (43.46%)
       581,780,465      L1-dcache-loads                  #    1.583 G/sec                        (44.46%)
         8,034,768      L1-dcache-load-misses            #    1.38% of all L1-dcache accesses   (44.14%)
   <not supported>      LLC-loads
   <not supported>      LLC-load-misses
       614,806,629      L1-icache-loads                  #    1.673 G/sec                        (43.79%)
         2,846,706      L1-icache-load-misses            #    0.46% of all L1-icache accesses   (43.40%)
         4,898,237      dTLB-loads                       #   13.326 M/sec                        (42.99%)
            20,369      dTLB-load-misses                 #    0.42% of all dTLB cache accesses  (42.56%)
            10,648      iTLB-loads                       #   28.968 K/sec                        (42.70%)
         1,216,136      iTLB-load-misses                 # 11421.26% of all iTLB cache accesses  (42.78%)
         1,034,734      L1-dcache-prefetches             #    2.815 M/sec                        (42.49%)
   <not supported>      L1-dcache-prefetch-misses

       0.366835563 seconds time elapsed

       0.053239000 seconds user
       0.314416000 seconds sys
```

logs > triple > both_opt > top.log

```
top - 07:26:21 up 2 days, 19:37,  1 user,  load average: 3.22, 3.00, 2.57
Tasks: 474 total,   1 running, 417 sleeping,  56 stopped,   0 zombie
%Cpu(s): 17.9 us, 82.1 sy,  0.0 ni,  0.0 id,  0.0 wa,  0.0 hi,  0.0 si,  0.0 st
MiB Mem :  15808.0 total,    648.8 free,   5597.8 used,  10109.1 buff/cache
MiB Swap:   4096.0 total,   4094.2 free,      1.8 used.  10210.2 avail Mem

    PID USER      PR  NI    VIRT    RES    SHR S  %CPU  %MEM     TIME+ COMMAND
 419670 root      20   0  153824   3560   3328 S  92.3   0.0   0:00.24 bothOpt+
 419671 root      20   0  153824   3692   3456 S  92.3   0.0   0:00.24 bothOpt+
 419672 root      20   0  153824   3688   3456 S  92.3   0.0   0:00.24 bothOpt+
 419673 root      20   0  153824   3692   3456 S  92.3   0.0   0:00.24 bothOpt+
 419674 root      20   0  153824   3688   3456 S  92.3   0.0   0:00.24 bothOpt+
 419676 root      20   0  153824   3692   3456 S  92.3   0.0   0:00.23 bothOpt+
 419677 root      20   0  153824   3692   3456 S  92.3   0.0   0:00.24 bothOpt+
 419679 root      20   0  153824   3688   3456 S  92.3   0.0   0:00.24 bothOpt+
 419680 root      20   0  153824   3692   3456 S  92.3   0.0   0:00.23 bothOpt+
 419684 root      20   0  153824   3560   3328 S  92.3   0.0   0:00.24 bothOpt+
 419689 root      20   0  153824   3560   3328 S  92.3   0.0   0:00.23 bothOpt+
 419695 root      20   0  153824   3692   3456 S  92.3   0.0   0:00.24 bothOpt+
 419669 root      20   0  153824   3560   3328 S  84.6   0.0   0:00.23 bothOpt+
 419675 root      20   0  153824   3676   3456 S  84.6   0.0   0:00.22 bothOpt+
 419678 root      20   0  153824   3688   3456 S  76.9   0.0   0:00.21 bothOpt+
 419681 root      20   0  153824   3432   3200 S  76.9   0.0   0:00.21 bothOpt+
```



100000000 | 100000 итераций

logs > quad > both_opt > ltrace.log

```
% time     seconds  usecs/call     calls      function
------ ----------- ----------- --------- --------------------
100.00  144.309833    72154916         2 _ZNSt6thread4joinEv
  0.00    0.000841         420         2 _ZNSt6thread15_M_start_threadESt10unique_ptrINS_6_StateESt14default_deleteIS1_EEPFvvE
  0.00    0.000195          97         2 __isoc23_strtol
  0.00    0.000171          85         2 _Znwm
------ ----------- ----------- --------- --------------------
100.00  144.311040                     8 total
```

logs > quad > both_opt > strace.log

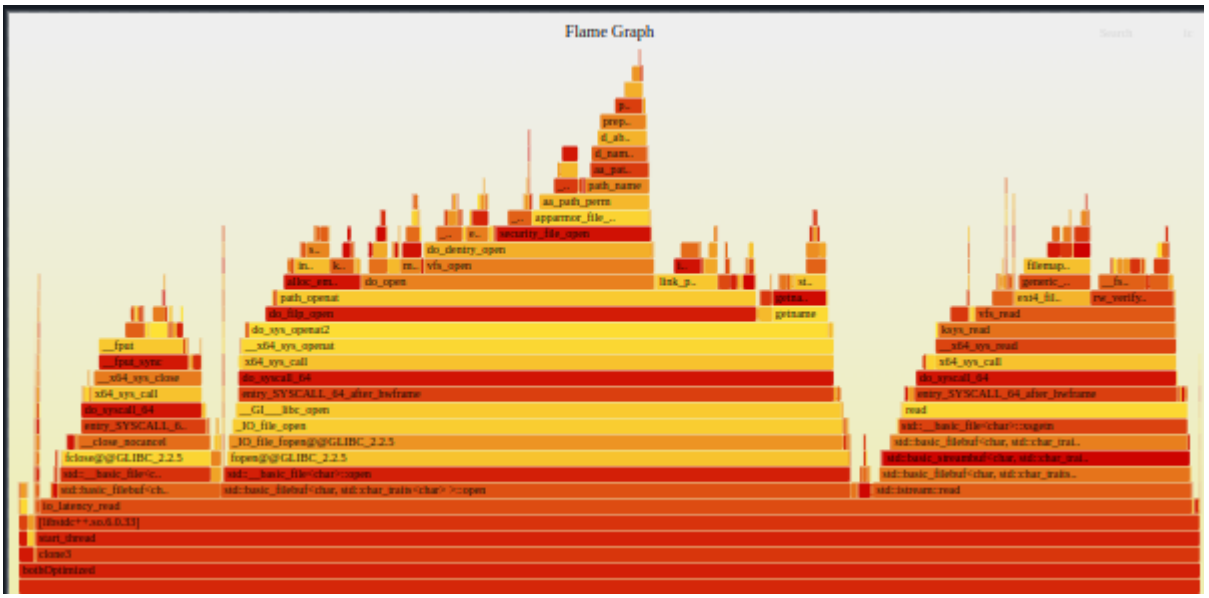
```
% time     seconds  usecs/call     calls    errors syscall
------ ----------- ----------- --------- --------- ----------------
 99.88    0.413628      137876         3           futex
  0.04    0.000150           6        24           mmap
  0.03    0.000129          16         8           mprotect
  0.01    0.000045          22         2           clone3
  0.01    0.000024           4         5           rt_sigprocmask
  0.01    0.000022           4         5           openat
  0.00    0.000019           3         5           close
  0.00    0.000015          15         1           munmap
  0.00    0.000015           5         3           brk
  0.00    0.000013           2         5           fstat
  0.00    0.000011           2         4           read
  0.00    0.000008           4         2           pread64
  0.00    0.000007           7         1           prlimit64
  0.00    0.000005           5         1           getrandom
  0.00    0.000004           4         1           rt_sigaction
  0.00    0.000003           3         1           arch_prctl
  0.00    0.000003           3         1           set_tid_address
  0.00    0.000003           3         1           set_robust_list
  0.00    0.000003           3         1           rseq
  0.00    0.000000           0         1         1 access
  0.00    0.000000           0         1           execve
------ ----------- ----------- --------- --------- ----------------
100.00    0.414107        5448        76         1 total
```

logs > quad > both_opt > perf.log

```
Performance counter stats for './../exec/bothOptimized ./../shell.cpp 100000 100000000':

            509.91 msec task-clock                       #    0.999 CPUs utilized
                91      context-switches                 #  178.462 /sec
                13      cpu-migrations                   #   25.495 /sec
             1,116      page-faults                      #    2.189 K/sec
     2,217,655,828      cycles                           #    4.349 GHz                         (43.03%)
       797,805,083      stalled-cycles-frontend          #   35.98% frontend cycles idle        (43.18%)
     1,940,474,100      instructions                     #    0.88  insn per cycle
                                                   #    0.41  stalled cycles per insn     (43.40%)
       412,641,367      branches                         #  809.239 M/sec                       (43.65%)
        42,981,734      branch-misses                    #   10.42% of all branches             (43.75%)
       801,829,834      L1-dcache-loads                  #    1.572 G/sec                        (43.56%)
        12,319,771      L1-dcache-load-misses            #    1.54% of all L1-dcache accesses   (43.44%)
   <not supported>      LLC-loads
   <not supported>      LLC-load-misses
       822,413,097      L1-icache-loads                  #    1.613 G/sec                        (43.18%)
         4,253,019      L1-icache-load-misses            #    0.52% of all L1-icache accesses   (42.78%)
         6,686,054      dTLB-loads                       #   13.112 M/sec                        (42.37%)
           125,572      dTLB-load-misses                 #    1.88% of all dTLB cache accesses  (42.25%)
           119,625      iTLB-loads                       #  234.599 K/sec                        (42.95%)
         1,595,339      iTLB-load-misses                 # 1333.62% of all iTLB cache accesses  (42.90%)
         1,692,202      L1-dcache-prefetches             #    3.319 M/sec                        (42.99%)
   <not supported>      L1-dcache-prefetch-misses

       0.510229172 seconds time elapsed

       0.091367000 seconds user
       0.418105000 seconds sys
```

logs > quad > both_opt > top.log

```
top - 07:34:50 up 2 days, 19:46,  1 user,  load average: 3.21, 3.47, 3.01
Tasks: 470 total,   2 running, 412 sleeping,  56 stopped,   0 zombie
%Cpu(s): 39.6 us, 59.9 sy,  0.5 ni,  0.0 id,  0.0 wa,  0.0 hi,  0.0 si,  0.0 st
MiB Mem :  15808.0 total,    996.8 free,   5243.3 used,  10070.3 buff/cache
MiB Swap:   4096.0 total,   4094.2 free,      1.8 used.  10564.7 avail Mem

    PID USER      PR  NI    VIRT    RES    SHR S  %CPU  %MEM     TIME+ COMMAND
 303857 junayd    20   0 1158.0g 591452 177052 R 176.9   3.7  25:39.17 chrome
 422224 root      20   0  153824   3692   3456 S 100.0   0.0   0:00.25 bothOpt+
 422232 root      20   0  153824   3688   3456 S 100.0   0.0   0:00.23 bothOpt+
 422245 root      20   0  153824   3692   3456 S 100.0   0.0   0:00.24 bothOpt+
 422223 root      20   0  153824   3560   3328 S  92.3   0.0   0:00.20 bothOpt+
 422225 root      20   0  153824   3688   3456 S  92.3   0.0   0:00.23 bothOpt+
 422227 root      20   0  153824   3688   3456 S  92.3   0.0   0:00.19 bothOpt+
 422234 root      20   0  153824   3560   3328 S  92.3   0.0   0:00.19 bothOpt+
 422228 root      20   0  153824   3560   3328 S  84.6   0.0   0:00.18 bothOpt+
 422230 root      20   0  153824   3692   3456 S  84.6   0.0   0:00.23 bothOpt+
 422231 root      20   0  153824   3688   3456 S  84.6   0.0   0:00.18 bothOpt+
 422233 root      20   0  153824   3560   3328 S  84.6   0.0   0:00.21 bothOpt+
 422235 root      20   0  153824   3560   3328 S  84.6   0.0   0:00.21 bothOpt+
 422244 root      20   0  153824   3688   3456 S  84.6   0.0   0:00.18 bothOpt+
 422226 root      20   0  153824   3560   3328 S  76.9   0.0   0:00.17 bothOpt+
 422248 root      20   0  153824   3692   3456 S  76.9   0.0   0:00.19 bothOpt+
 422229 root      20   0  153824   3688   3456 S  38.5   0.0   0:00.07 bothOpt+
```



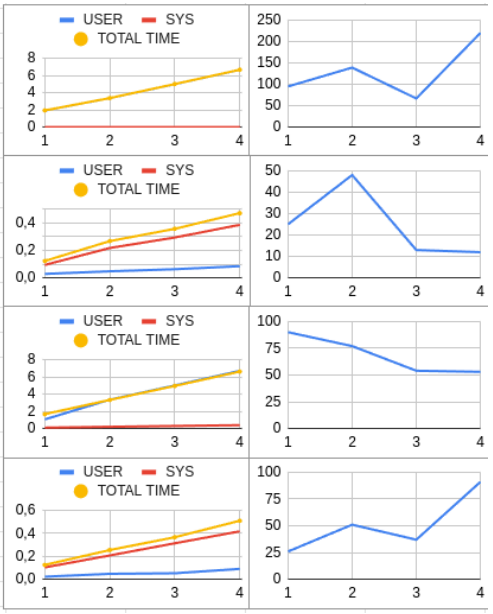
Сравнительный анализ ожидаемых и фактических значений

binSearch	1	2	3	4
USER	1,936	3,372	4,995	6,66
SYS	0,007	0,004	0,007	0,004
CS	95	139	67	220
TOTAL TIME	1,945	3,379	5,005	6,67

ioLatRead	1	2	3	4
USER	0,029	0,048	0,063	0,0849
SYS	0,094	0,217	0,293	0,385
CS	25	48	13	12
TOTAL TIME	0,123	0,267	0,356	0,47

both	1	2	3	4
USER	1,07	3,362	5,014	6,711
SYS	0,112	0,213	0,31	0,403
CS	90	77	54	53
TOTAL TIME	1,686	3,332	4,956	6,622

both_opt	1	2	3	4
USER	0,023	0,048	0,053	0,091
SYS	0,104	0,208	0,314	0,418
CS	26	51	37	91
TOTAL TIME	0,126	0,255	0,367	0,51



На таблицах и графиках представлены основные метрики (USER, SYS, ContextSwitches, Time Elapsed).
По результатам анализа можно сделать вывод, что предположения об отношениях времени системных и пользовательских процессов оказались верны.
Большинство метрик возрастают с увеличением числа итераций, что также следовало ожидать. При этом у алгоритмов, несильно полагающихся на системное время, оно не демонстрирует значительную линейность.
О зависимости числа переключений контекста от числа итераций в данном контексте судить тяжело, так как на него сильно влияют алгоритмы планирования внутри самой ОС.

После компиляции комбинированного нагрузчика пользовательское и реальное время исполнения значительно сократились, системное время при этом

практически не изменилось, что также предполагалось перед проведением эксперимента.

Вывод

За время работы я изучил основные инструменты профилирования, мониторинга и трассировки в Linux и провел эксперимент по измерению метрик для алгоритмов с различными свойствами при различных уровнях нагрузки на систему.