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Факультет программной инженерии и компьютерной техники

Дисциплина:

“Операционные системы”

Отчет по лабораторной работе № 1

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[Репозиторий лабораторной.](#)

▼ Вариант

```
1 {
2   target_os: 'Linux',
3   fork_kind: 'fork',
4   bench: {
5     0: 'ema-sort-int',
6     1: 'bin-search'
7   }
8 }
```

```
debian@debian:~/Documents/shell$ neofetch
      _met$$$$$gg.          debian@debian
     ,g$$$$$$$$$$$$$$$$$P.  -----
  ,g$$P"      ""Y$$. .      OS: Debian GNU/Linux 12 (bookworm) aarch64
,$$P'           '$$$.      Host: QEMU Virtual Machine virt-7.2
,$$P      ,ggs.      '$$b:  Kernel: 6.1.0-13-arm64
`d$$'      ,$P"'.      $$$  Uptime: 1 hour, 48 mins
$$P      d$'.      $$P  Packages: 1662 (dpkg)
$$:      $$.-      ,d$$'  Shell: bash 5.2.15
$$;      Y$b._      ,d$P'  Resolution: 1800x1126
Y$$.      `."Y$$$P"'  DE: GNOME 43.6
`$$b      "-._      WM: Mutter
`Y$$.          WM Theme: Adwaita
`$$b.          Theme: Adwaita [GTK2/3]
`Y$$b.          Icons: Adwaita [GTK2/3]
`"Y$b._      Terminal: gnome-terminal
`"        `""      CPU: (6)
`GPU: 00:02.0 Red Hat, Inc. Virtio 1.0 GPU
`Memory: 2271MiB / 3921MiB
```



Часть 1. Запуск программ

Вам предстоит разработать собственную оболочку командной строки — **shell**. Выбор операционной системы остаётся за вами. **Shell** должен позволять пользователю запускать программы на компьютере с передачей аргументов командной строки. По завершении выполнения программы необходимо отображать реальное время её работы (рассчитывается как разница между «временем завершения» и «временем запуска»).

▼ shell.cpp

```
1 #include <iostream>
2 #include <vector>
3 #include <string>
4 #include <sstream>
5 #include <sys/types.h>
6 #include <sys/wait.h>
7 #include <unistd.h>
8 #include <cstdlib>
```

```

9 #include <chrono>
10
11 using namespace std;
12
13 vector<string> parseCommand(const string& input) {
14     istringstream iss(input);
15     vector<string> tokens;
16     string token;
17     while (iss >> token) {
18         tokens.push_back(token);
19     }
20     return tokens;
21 }
22
23 int execute(const vector<string>& args) {
24     if (args.empty()) return -1;
25
26     auto start = chrono::high_resolution_clock::now();
27     pid_t pid = fork();
28
29     if (pid < 0) {
30         perror("Error: Failed to create a new process");
31         return -1;
32     } else if (pid == 0) {
33         vector<char*> c_args;
34         for (const auto& arg : args) {
35             c_args.push_back(const_cast<char*>(arg.c_str()));
36         }
37         c_args.push_back(nullptr);
38
39         if (execvp(c_args[0], c_args.data()) == -1) {
40             perror("Error: Command execution failed");
41             exit(EXIT_FAILURE);
42         }
43     } else {
44         int status;
45         if (waitpid(pid, &status, 0) == -1) {
46             perror("Error: waitpid failed");
47             return -1;
48         }
49         auto end = chrono::high_resolution_clock::now();
50         auto duration = chrono::duration_cast<chrono::milliseconds>(end - start);
51         cout << "\nExecution time: " << duration.count() << "ms" << endl;
52         return WEXITSTATUS(status);
53     }
54     return 0;
55 }
56
57 void process() {
58     while (true) {
59         cout << "> ";
60         string command;
61         getline(cin, command);
62
63         vector<string> args = parseCommand(command);
64
65         if (args.empty()) continue;
66         if (args[0] == "quit") break;
67
68         int status = execute(args);
69         if (status != 0) {
70             cout << "Command exited with status: " << status << endl;
71         }
72     }
73 }
```

```
74
75 int main() {
76     process();
77     return 0;
78 }
79
```

Часть 2. Мониторинг и профилирование

Предстоит разработать комплекс программ-нагрузчиков согласно варианту, указанному преподавателем. Каждый нагрузчик должен принимать как минимум один параметр, определяющий количество повторений для алгоритма. Программы должны нагружать вычислительную систему, дисковую подсистему или обе одновременно. Компиляция должна происходить без использования опций оптимизации компилятора.

Этапы работы:

1. *Постарайтесь оценить время работы программы-нагрузчика или её результаты (если необходимо измерение). Обоснуйте свои предположения, основываясь на знании ОС, опыте и характеристиках оборудования.*

Бинарный поиск

- **%USER**: высокий, так как основная часть работы связана с вычислениями и сравнениями элементов массива.
- **%SYS**: низкий, так как алгоритм не требует частых системных вызовов.
- **%WAIT**: низкий, так как алгоритм не зависит от ввода-вывода и работы диска.
- **Реальное время выполнения**: $\log(n)/10^9$ с, для $n = 100000$, $\log(100000)/10^9 \approx 0.000000005$ с, плюс время, затраченное на создание массива для поиска в нём (оно линейно).
- **Переключения контекста**: минимальные.

Внешняя сортировка чисел

- **%USER**: умеренный, так как часть работы связана с сортировкой блоков в оперативной памяти.
- **%SYS**: высокий из-за частых обращений к файловой системе для чтения и записи блоков данных.
- **%WAIT**: высокий из-за работы диска, особенно при слиянии блоков.
- **Реальное время выполнения**: $O(n \log n)$, где n — количество элементов.
- **Переключения контекста**: частые из-за необходимости управления вводом-выводом и системными вызовами.

2. *Запустите программу-нагрузчик и зафиксируйте её метрики с помощью инструментов профилирования. Сравните результаты с ожидаемыми и постарайтесь их объяснить.*

Бинарный поиск

```
▼ command
1 time ./load_tester bin-search 1 100000
```

```
debian@debian:~/Documents/shell$ time ./load_tester bin-search 1 100000
CPU load completed with 1 threads and 100000 iterations per thread. Execution time: 1.89234 seconds.
```

```
real    0m1.895s
user    0m1.895s
sys     0m0.000s
```

```
▼ command
```

```
1 sudo perf stat -e task-clock,context-switches,cpu-migrations,page-faults,cycles,instructions ./load_tester bin-search 1 100000
```

```
debian@debian:~/Documents/shell$ sudo perf stat -e task-clock,context-switches,cpu-migrations,page-faults,cycles,instructions ./load_tester bin-search 1 100000
CPU load completed with 1 threads and 100000 iterations per thread. Execution time: 1.90274 seconds.
```

Performance counter stats for './load_tester bin-search 1 100000':

| | | |
|-----------------|------------------|-----------------------|
| 1,903.88 msec | task-clock | # 1.000 CPUs utilized |
| 9 | context-switches | # 4.727 /sec |
| 0 | cpu-migrations | # 0.000 /sec |
| 125 | page-faults | # 65.656 /sec |
| <not supported> | cycles | |
| <not supported> | instructions | |

1.904296998 seconds time elapsed
1.904392000 seconds user
0.000000000 seconds sys

Внешняя сортировка чисел

▼ command

```
1 time ./load_tester ema-sort-int 1 100000
```

```
debian@debian:~/Documents/shell$ time ./load_tester ema-sort-int 1 100000
CPU load completed with 1 threads and 100000 iterations per thread. Execution time: 26.0818 seconds.
```

| | |
|------|-----------|
| real | 0m26.085s |
| user | 0m23.935s |
| sys | 0m2.094s |

▼ command

```
1 sudo perf stat -e task-clock,context-switches,cpu-migrations,page-faults,cycles,instructions ./load_tester ema-sort-int 1 100000
```

```
debian@debian:~/Documents/shell$ sudo perf stat -e task-clock,context-switches,cpu-migrations,page-faults,cycles,instructions ./load_tester ema-sort-int 1 100000
CPU load completed with 1 threads and 100000 iterations per thread. Execution time: 25.9524 seconds.
```

Performance counter stats for './load_tester ema-sort-int 1 100000':

| | | |
|-----------------|------------------|-----------------------|
| 25,899.26 msec | task-clock | # 0.998 CPUs utilized |
| 3,219 | context-switches | # 124.289 /sec |
| 1 | cpu-migrations | # 0.039 /sec |
| 128 | page-faults | # 4.942 /sec |
| <not supported> | cycles | |
| <not supported> | instructions | |

25.953769538 seconds time elapsed
23.812174000 seconds user
2.084164000 seconds sys

3. **Определите количество нагрузчиков, эффективно использующих все ядра процессора.**

Изучите распределение времени USER%, SYS%, WAIT%, реальное время выполнения и количество переключений контекста.

Бинарный поиск

▼ command

```
1 time ./parallels 3 ./load_tester bin-search 1 1000000
```

```

0[          0.0%] 3[          0.0%]
1[||| 100.0%] 4[||||| 100.0%]
2[| 0.7%] 5[||||| 100.0%]
Mem[||||| 901M/3.83G] Tasks: 110, 244 thr, 90 kthr; 4 running
Swp[      0K/976M] Load average: 1.86 1.14 0.52
Uptime: 00:33:04

```

| Main | I/O | PID | USER | PRI | NI | VIRT | RES | SHR | S | CPU% | MEM% | TIME+ | Command |
|------|-----|------|--------|-----|----|-------|------|------|---|-------|------|---------|------------------------------------|
| | | 3362 | debian | 20 | 0 | 78976 | 1668 | 1500 | S | 101.4 | 0.0 | 0:04.99 | ./load_tester bin-search 1 1000000 |
| | | 3360 | debian | 20 | 0 | 78976 | 3716 | 1500 | S | 100.8 | 0.1 | 0:04.99 | ./load_tester bin-search 1 1000000 |
| | | 3361 | debian | 20 | 0 | 78976 | 1668 | 1500 | S | 100.8 | 0.0 | 0:04.99 | ./load_tester bin-search 1 1000000 |
| | | 3363 | debian | 20 | 0 | 78976 | 1668 | 1500 | R | 100.8 | 0.0 | 0:04.98 | ./load_tester bin-search 1 1000000 |
| | | 3364 | debian | 20 | 0 | 78976 | 1668 | 1500 | R | 100.8 | 0.0 | 0:04.98 | ./load_tester bin-search 1 1000000 |
| | | 3365 | debian | 20 | 0 | 78976 | 3716 | 1500 | R | 100.8 | 0.1 | 0:04.98 | ./load_tester bin-search 1 1000000 |

```

debian@debian:~/Documents/shell$ time ./parallels 3 ./load_tester bin-search 1 1000000
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 20.3372 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 20.3421 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 20.3556 seconds.

```

```

real    0m20.367s
user    1m1.042s
sys     0m0.014s

```

▼ command

```
1 time ./parallels 5 ./load_tester bin-search 1 1000000
```

```

0[          0.0%] 3[          0.0%]
1[||| 1.3%] 4[||||| 100.0%]
2[| 100.0%] 5[||||| 100.0%]
Mem[||||| 900M/3.83G] Tasks: 112, 246 thr, 90 kthr; 6 running
Swp[      0K/976M] Load average: 1.06 1.04 0.56
Uptime: 00:34:59

```

| Main | I/O | PID | USER | PRI | NI | VIRT | RES | SHR | S | CPU% | MEM% | TIME+ | Command |
|------|-----|------|--------|-----|----|-------|------|------|---|-------|------|---------|---------------------------------------|
| | | 3369 | debian | 20 | 0 | 78976 | 1668 | 1500 | S | 101.3 | 0.0 | 0:04.24 | ./load_tester bin-search 1 1000000 |
| | | 3370 | debian | 20 | 0 | 78976 | 1668 | 1500 | S | 101.3 | 0.0 | 0:04.24 | ./load_tester bin-search 1 1000000 |
| | | 3371 | debian | 20 | 0 | 78976 | 1668 | 1500 | S | 101.3 | 0.0 | 0:04.24 | ./load_tester bin-search 1 1000000 |
| | | 3372 | debian | 20 | 0 | 78976 | 1668 | 1500 | S | 101.3 | 0.0 | 0:04.23 | ./load_tester bin-search 1 1000000 |
| | | 3373 | debian | 20 | 0 | 78976 | 1668 | 1500 | S | 101.3 | 0.0 | 0:04.23 | ./load_tester bin-search 1 1000000 |
| | | 3374 | debian | 20 | 0 | 78976 | 1668 | 1500 | R | 101.3 | 0.0 | 0:04.24 | ./load_tester bin-search 1 1000000 |
| | | 3375 | debian | 20 | 0 | 78976 | 1668 | 1500 | R | 101.3 | 0.0 | 0:04.24 | ./load_tester bin-search 1 1000000 |
| | | 3376 | debian | 20 | 0 | 78976 | 1668 | 1500 | R | 101.3 | 0.0 | 0:04.24 | ./load_tester bin-search 1 1000000 |
| | | 3377 | debian | 20 | 0 | 78976 | 1668 | 1500 | R | 101.3 | 0.0 | 0:04.23 | ./load_tester bin-search 1 1000000 |
| | | 3378 | debian | 20 | 0 | 78976 | 1668 | 1500 | R | 101.3 | 0.0 | 0:04.23 | ./load_tester bin-search 1 1000000 |
| | | 3368 | debian | 20 | 0 | 5136 | 1628 | 1460 | S | 0.0 | 0.0 | 0:00.00 | ./parallels 5 ./load_tester bin-searc |

```

sys      0m0.014s
debian@debian:~/Documents/shell$ time ./parallels 5 ./load_tester bin-search 1 1000000
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 21.3549 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 21.3645 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 21.3727 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 21.3867 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 21.3921 seconds.

real    0m21.399s
user    1m46.792s
sys     0m0.027s
-
```

▼ command

```

1 time ./parallels 6 ./load_tester bin-search 1 1000000

```

```

0[|||||100.0%] 3[|||||100.0%]
1[|||||100.0%] 4[|||||100.0%]
2[|||||100.0%] 5[|||||100.0%]
Mem[|||||100.0%] 905M/3.83G] Tasks: 113, 247 thr, 90 kthr; 6 running
Swp[          0K/976M] Load average: 1.65 1.25 0.66
                           Uptime: 00:35:59

```

| Main | I/O | | | | | | | | | | |
|------|--------|-----|----|-------|------|------|---|-------|------|---------|------------------------------------|
| PID | USER | PRI | NI | VIRT | RES | SHR | S | CPU% | MEM% | TIME+ | Command |
| 3381 | debian | 20 | 0 | 78976 | 1668 | 1500 | S | 101.0 | 0.0 | 0:04.81 | ./load_tester bin-search 1 1000000 |
| 3382 | debian | 20 | 0 | 78976 | 1660 | 1492 | S | 101.0 | 0.0 | 0:04.86 | ./load_tester bin-search 1 1000000 |
| 3383 | debian | 20 | 0 | 78976 | 1664 | 1496 | S | 101.0 | 0.0 | 0:04.84 | ./load_tester bin-search 1 1000000 |
| 3384 | debian | 20 | 0 | 78976 | 1664 | 1496 | S | 101.0 | 0.0 | 0:04.84 | ./load_tester bin-search 1 1000000 |
| 3385 | debian | 20 | 0 | 78976 | 1668 | 1500 | S | 101.0 | 0.0 | 0:04.86 | ./load_tester bin-search 1 1000000 |
| 3387 | debian | 20 | 0 | 78976 | 1668 | 1500 | R | 101.0 | 0.0 | 0:04.81 | ./load_tester bin-search 1 1000000 |
| 3388 | debian | 20 | 0 | 78976 | 1664 | 1496 | R | 101.0 | 0.0 | 0:04.84 | ./load_tester bin-search 1 1000000 |
| 3389 | debian | 20 | 0 | 78976 | 1664 | 1496 | R | 101.0 | 0.0 | 0:04.84 | ./load_tester bin-search 1 1000000 |
| 3390 | debian | 20 | 0 | 78976 | 1660 | 1492 | R | 101.0 | 0.0 | 0:04.86 | ./load_tester bin-search 1 1000000 |
| 3391 | debian | 20 | 0 | 78976 | 1668 | 1500 | R | 101.0 | 0.0 | 0:04.86 | ./load_tester bin-search 1 1000000 |
| 3380 | debian | 20 | 0 | 78976 | 1668 | 1500 | S | 100.3 | 0.0 | 0:04.81 | ./load_tester bin-search 1 1000000 |
| 3386 | debian | 20 | 0 | 78976 | 1668 | 1500 | R | 100.3 | 0.0 | 0:04.80 | ./load_tester bin-search 1 1000000 |

```

sys     0m0.027s
debian@debian:~/Documents/shell$ time ./parallels 6 ./load_tester bin-search 1 1000000
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 22.0085 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 22.1203 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 22.1348 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 22.22 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 22.3506 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 22.3561 seconds.

real    0m22.359s
user    2m12.574s
sys     0m0.021s
-
```

▼ command

```

1 sudo perf stat -e task-clock,context-switches,cpu-migrations,page-faults,cycles,instructions ./parallels 6
./load_tester bin-search 1 1000000

```

```
debian@debian:~/Documents/shell$ sudo perf stat -e task-clock,context-switches,cpu-migrations,page-faults,cycles,instructions ./parallels 6 ./load_tester bin-search 1 1000000
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 21.7309 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 21.7978 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 21.8248 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 21.966 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 21.9758 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 21.9836 seconds.
```

Performance counter stats for './parallels 6 ./load_tester bin-search 1 1000000':

| | | |
|-----------------|------------------|-----------------------|
| 130,859.40 msec | task-clock | # 5.947 CPUs utilized |
| 1,245 | context-switches | # 9.514 /sec |
| 6 | cpu-migrations | # 0.046 /sec |
| 1,188 | page-faults | # 9.078 /sec |
| <not supported> | cycles | |
| <not supported> | instructions | |

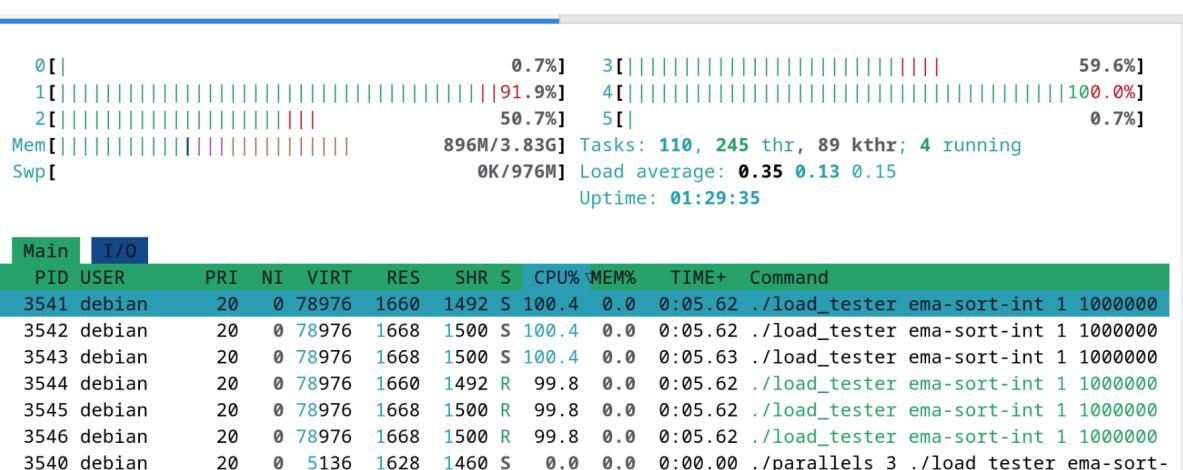
22.002733182 seconds time elapsed

130.759117000 seconds user
0.071572000 seconds sys

Внешняя сортировка чисел

▼ command

```
1 time ./parallels 3 ./load_tester ema-sort-int 1 1000000
```



```
debian@debian:~/Documents/shell$ time ./parallels 3 ./load_tester ema-sort-int 1 1000000
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 282.638 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 282.772 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 282.94 seconds.
```

```
real    4m42.949s
user    12m37.847s
sys     1m28.437s
```

▼ command

```
1 time ./parallels 6 ./load_tester ema-sort-int 1 1000000
```

```
debian@debian:~/Documents/shell$ time ./parallels 6 ./load_tester ema-sort-int 1 1000000
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 310.823 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 311.112 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 312.461 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 313.108 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 315.098 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 316.022 seconds.

real    5m16.027s
user    27m38.107s
sys     3m29.734s
```

```
0[|||||100.0%] 3[|||||100.0%]  
1[|||||100.0%] 4[|||||100.0%]  
2[|||||100.0%] 5[|||||100.0%]  
Mem[|||||100.0%] Tasks: 113, 247 thr, 89 kthr; 6 running  
Swp[ 0K/976M] Load average: 2.07 3.53 2.18  
Uptime: 01:41:35
```

Main I/O

▼ command

```
1 sudo perf stat -e task-clock,context-switches,cpu-migrations,page-faults,cycles,instructions ./parallels 6  
.load_tester ema-sort-int 1 1000000
```

```
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 311.171 seconds.  
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 311.395 seconds.  
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 311.583 seconds.  
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 311.658 seconds.  
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 311.668 seconds.  
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 311.749 seconds.
```

Performance counter stats for './parallels 6 ./load_tester ema-sort-int 1 1000000':

```
1,860,268.02 msec task-clock          #      5.967 CPUs utilized  
 320,290      context-switches       #   172.174 /sec  
     38        cpu-migrations        #      0.020 /sec  
  1,212      page-faults           #      0.652 /sec  
<not supported>    cycles  
<not supported>    instructions  
  
311.751802196 seconds time elapsed  
  
1647.438957000 seconds user  
211.425473000 seconds sys
```

debian@debian:~/Documents/shell\$ █

4. Увеличьте количество нагрузчиков в два, три и четыре раза. Как это повлияло на предыдущие метрики?

Бинарный поиск

▼ command

```
1 time ./parallels 12 ./load_tester bin-search 1 1000000
```

```
0[||||| 100.0%] 3[||||| 100.0%]
1[||||| 100.0%] 4[||||| 100.0%]
2[||||| 100.0%] 5[||||| 100.0%]
Mem[||||| 906M/3.83G] Tasks: 119, 254 thr, 89 kthr; 6 running
Swp[          0K/976M] Load average: 1.04 1.82 2.40
                           Uptime: 01:53:37
```

| Main | I/O | PID | User | PRI | NI | VIRT | RES | SHR | S | CPU% | MEM% | TIME+ | Command |
|------|--------|-----|------|-------|------|------|-----|------|-----|---------|----------------------------|---------|---------|
| 3678 | debian | 20 | 0 | 78976 | 1668 | 1500 | S | 51.4 | 0.0 | 0:02.31 | ./load_tester bin-search 1 | 1000000 | |
| 3690 | debian | 20 | 0 | 78976 | 1668 | 1500 | R | 51.4 | 0.0 | 0:02.31 | ./load_tester bin-search 1 | 1000000 | |
| 3676 | debian | 20 | 0 | 78976 | 1668 | 1500 | S | 50.8 | 0.0 | 0:02.29 | ./load_tester bin-search 1 | 1000000 | |
| 3680 | debian | 20 | 0 | 78976 | 3716 | 1500 | S | 50.8 | 0.1 | 0:02.31 | ./load_tester bin-search 1 | 1000000 | |
| 3683 | debian | 20 | 0 | 78976 | 1672 | 1500 | S | 50.8 | 0.0 | 0:02.34 | ./load_tester bin-search 1 | 1000000 | |
| 3688 | debian | 20 | 0 | 78976 | 1668 | 1500 | S | 50.8 | 0.0 | 0:02.32 | ./load_tester bin-search 1 | 1000000 | |
| 3689 | debian | 20 | 0 | 78976 | 1672 | 1500 | S | 50.8 | 0.0 | 0:02.30 | ./load_tester bin-search 1 | 1000000 | |
| 3695 | debian | 20 | 0 | 78976 | 1672 | 1500 | R | 50.8 | 0.0 | 0:02.34 | ./load_tester bin-search 1 | 1000000 | |
| 3696 | debian | 20 | 0 | 78976 | 1668 | 1500 | R | 50.8 | 0.0 | 0:02.32 | ./load_tester bin-search 1 | 1000000 | |
| 3697 | debian | 20 | 0 | 78976 | 1668 | 1500 | R | 50.8 | 0.0 | 0:02.28 | ./load_tester bin-search 1 | 1000000 | |
| 3699 | debian | 20 | 0 | 78976 | 3716 | 1500 | R | 50.8 | 0.1 | 0:02.31 | ./load_tester bin-search 1 | 1000000 | |
| 3677 | debian | 20 | 0 | 78976 | 1668 | 1500 | S | 50.1 | 0.0 | 0:02.30 | ./load_tester bin-search 1 | 1000000 | |
| 3679 | debian | 20 | 0 | 78976 | 1668 | 1500 | S | 50.1 | 0.0 | 0:02.29 | ./load_tester bin-search 1 | 1000000 | |
| 3681 | debian | 20 | 0 | 78976 | 1668 | 1500 | S | 50.1 | 0.0 | 0:02.27 | ./load_tester bin-search 1 | 1000000 | |
| 3685 | debian | 20 | 0 | 78976 | 1668 | 1500 | R | 50.1 | 0.0 | 0:02.29 | ./load_tester bin-search 1 | 1000000 | |
| 3686 | debian | 20 | 0 | 78976 | 1668 | 1500 | R | 50.1 | 0.0 | 0:02.28 | ./load_tester bin-search 1 | 1000000 | |
| 3691 | debian | 20 | 0 | 78976 | 1668 | 1500 | R | 50.1 | 0.0 | 0:02.30 | ./load_tester bin-search 1 | 1000000 | |
| 3682 | debian | 20 | 0 | 78976 | 1668 | 1500 | S | 49.4 | 0.0 | 0:02.29 | ./load_tester bin-search 1 | 1000000 | |
| 3684 | debian | 20 | 0 | 78976 | 3716 | 1500 | S | 49.4 | 0.1 | 0:02.27 | ./load_tester bin-search 1 | 1000000 | |
| 3687 | debian | 20 | 0 | 78976 | 1668 | 1500 | S | 49.4 | 0.0 | 0:02.29 | ./load_tester bin-search 1 | 1000000 | |
| 3692 | debian | 20 | 0 | 78976 | 3716 | 1500 | R | 49.4 | 0.1 | 0:02.27 | ./load_tester bin-search 1 | 1000000 | |
| 3693 | debian | 20 | 0 | 78976 | 1668 | 1500 | R | 49.4 | 0.0 | 0:02.29 | ./load_tester bin-search 1 | 1000000 | |
| 3694 | debian | 20 | 0 | 78976 | 1668 | 1500 | R | 49.4 | 0.0 | 0:02.29 | ./load_tester bin-search 1 | 1000000 | |
| 3698 | debian | 20 | 0 | 78976 | 1672 | 1500 | R | 49.4 | 0.0 | 0:02.29 | ./load_tester bin-search 1 | 1000000 | |

▼ command

```
1 sudo perf stat -e task-clock,context-switches,cpu-migrations,page-faults,cycles,instructions ./parallels  
24 ./load_tester bin-search 1 1000000
```

```

0[|||||100.0%] 3[|||||100.0%]
1[|||||100.0%] 4[|||||100.0%]
2[|||||100.0%] 5[|||||100.0%]
Mem[|||||100.0%] 916M/3.83G] Tasks: 134, 266 thr, 90 kthr; 6 running
Swp[          0K/976M] Load average: 4.97 3.08 2.81
                                         Uptime: 01:55:04

```

| Main | I/O | PID | USER | PRI | NI | VIRT | RES | SHR | S | CPU% | MEM% | TIME+ | Command |
|------|-----|------|------|-----|----|-------|------|------|---|------|------|---------|------------------------------------|
| | | 3737 | root | 20 | 0 | 78976 | 1668 | 1500 | R | 32.1 | 0.0 | 0:01.69 | ./load_tester bin-search 1 1000000 |
| | | 3711 | root | 20 | 0 | 78976 | 1668 | 1500 | S | 32.1 | 0.0 | 0:01.69 | ./load_tester bin-search 1 1000000 |
| | | 3712 | root | 20 | 0 | 78976 | 1656 | 1488 | S | 22.7 | 0.0 | 0:01.46 | ./load_tester bin-search 1 1000000 |
| | | 3732 | root | 20 | 0 | 78976 | 1656 | 1488 | R | 22.7 | 0.0 | 0:01.46 | ./load_tester bin-search 1 1000000 |
| | | 3735 | root | 20 | 0 | 78976 | 3716 | 1500 | R | 22.7 | 0.1 | 0:01.46 | ./load_tester bin-search 1 1000000 |
| | | 3707 | root | 20 | 0 | 78976 | 3716 | 1500 | S | 23.4 | 0.1 | 0:01.46 | ./load_tester bin-search 1 1000000 |
| | | 3709 | root | 20 | 0 | 78976 | 1668 | 1500 | S | 24.1 | 0.0 | 0:01.47 | ./load_tester bin-search 1 1000000 |
| | | 3713 | root | 20 | 0 | 78976 | 1668 | 1500 | S | 22.7 | 0.0 | 0:01.46 | ./load_tester bin-search 1 1000000 |
| | | 3741 | root | 20 | 0 | 78976 | 1668 | 1500 | R | 22.7 | 0.0 | 0:01.46 | ./load_tester bin-search 1 1000000 |
| | | 3719 | root | 20 | 0 | 78976 | 1668 | 1500 | S | 26.1 | 0.0 | 0:01.55 | ./load_tester bin-search 1 1000000 |
| | | 3721 | root | 20 | 0 | 78976 | 1668 | 1500 | S | 26.7 | 0.0 | 0:01.51 | ./load_tester bin-search 1 1000000 |
| | | 3722 | root | 20 | 0 | 78976 | 1668 | 1500 | R | 24.1 | 0.0 | 0:01.47 | ./load_tester bin-search 1 1000000 |
| | | 3734 | root | 20 | 0 | 78976 | 1668 | 1500 | R | 26.7 | 0.0 | 0:01.51 | ./load_tester bin-search 1 1000000 |
| | | 3740 | root | 20 | 0 | 78976 | 1668 | 1500 | R | 26.1 | 0.0 | 0:01.55 | ./load_tester bin-search 1 1000000 |
| | | 3705 | root | 20 | 0 | 78976 | 1656 | 1488 | S | 25.4 | 0.0 | 0:01.48 | ./load_tester bin-search 1 1000000 |
| | | 3706 | root | 20 | 0 | 78976 | 1668 | 1500 | S | 26.1 | 0.0 | 0:01.49 | ./load_tester bin-search 1 1000000 |
| | | 3717 | root | 20 | 0 | 78976 | 1668 | 1500 | R | 26.7 | 0.0 | 0:01.49 | ./load_tester bin-search 1 1000000 |
| | | 3723 | root | 20 | 0 | 78976 | 1668 | 1500 | S | 24.7 | 0.0 | 0:01.46 | ./load_tester bin-search 1 1000000 |
| | | 3724 | root | 20 | 0 | 78976 | 1668 | 1500 | S | 28.7 | 0.0 | 0:01.53 | ./load_tester bin-search 1 1000000 |
| | | 3725 | root | 20 | 0 | 78976 | 1668 | 1500 | S | 26.1 | 0.0 | 0:01.48 | ./load_tester bin-search 1 1000000 |
| | | 3726 | root | 20 | 0 | 78976 | 1668 | 1500 | S | 22.0 | 0.0 | 0:01.44 | ./load_tester bin-search 1 1000000 |
| | | 3729 | root | 20 | 0 | 78976 | 1660 | 1492 | S | 22.7 | 0.0 | 0:01.43 | ./load_tester bin-search 1 1000000 |
| | | 3744 | root | 20 | 0 | 78976 | 1668 | 1500 | R | 24.7 | 0.0 | 0:01.46 | ./load_tester bin-search 1 1000000 |
| | | 3745 | root | 20 | 0 | 78976 | 1668 | 1500 | R | 29.4 | 0.0 | 0:01.53 | ./load_tester bin-search 1 1000000 |
| | | 3747 | root | 20 | 0 | 78976 | 1668 | 1500 | R | 26.1 | 0.0 | 0:01.48 | ./load_tester bin-search 1 1000000 |
| | | 3749 | root | 20 | 0 | 78976 | 1668 | 1500 | R | 22.7 | 0.0 | 0:01.44 | ./load_tester bin-search 1 1000000 |
| | | 3750 | root | 20 | 0 | 78976 | 1660 | 1492 | R | 22.7 | 0.0 | 0:01.43 | ./load_tester bin-search 1 1000000 |
| | | 3708 | root | 20 | 0 | 78976 | 1668 | 1500 | S | 23.4 | 0.0 | 0:01.44 | ./load_tester bin-search 1 1000000 |
| | | 3714 | root | 20 | 0 | 78976 | 1656 | 1488 | R | 25.4 | 0.0 | 0:01.48 | ./load_tester bin-search 1 1000000 |
| | | 3716 | root | 20 | 0 | 78976 | 1668 | 1500 | S | 31.4 | 0.0 | 0:01.54 | ./load_tester bin-search 1 1000000 |
| | | 3720 | root | 20 | 0 | 78976 | 1668 | 1500 | S | 25.4 | 0.0 | 0:01.47 | ./load_tester bin-search 1 1000000 |
| | | 3727 | root | 20 | 0 | 78976 | 3716 | 1500 | S | 31.4 | 0.1 | 0:01.56 | ./load_tester bin-search 1 1000000 |
| | | 3746 | root | 20 | 0 | 78976 | 3716 | 1500 | R | 32.1 | 0.1 | 0:01.56 | ./load_tester bin-search 1 1000000 |
| | | 3752 | root | 20 | 0 | 78976 | 1668 | 1500 | R | 23.4 | 0.0 | 0:01.44 | ./load_tester bin-search 1 1000000 |

```
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 88.274 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 88.2751 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 88.6513 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 88.6979 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 88.8053 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 88.7955 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 88.8768 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 89.0234 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 89.03 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 89.0267 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 89.0472 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 89.0575 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 89.1435 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 89.1567 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 89.2638 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 89.3675 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 89.362 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 89.387 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 89.3586 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 89.4267 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 89.4766 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 89.4805 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 89.5401 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 89.5511 seconds.
```

```
Performance counter stats for './parallels 24 ./load_tester bin-search 1 1000000':
```

| | | |
|-----------------|------------------|-----------------------|
| 534,788.86 msec | task-clock | # 5.972 CPUs utilized |
| 70,179 | context-switches | # 131.227 /sec |
| 252 | cpu-migrations | # 0.471 /sec |
| 4,308 | page-faults | # 8.056 /sec |
| <not supported> | cycles | |
| <not supported> | instructions | |


```
89.555740144 seconds time elapsed

534.431483000 seconds user
 0.216265000 seconds sys
```

Внешняя сортировка чисел

▼ command

```
1 time ./parallels 12 ./load_tester ema-sort-int 1 100000
```

```
CPU load completed with 1 threads and 100000 iterations per thread. Execution time: 62.0064 seconds.
CPU load completed with 1 threads and 100000 iterations per thread. Execution time: 62.038 seconds.
CPU load completed with 1 threads and 100000 iterations per thread. Execution time: 62.3396 seconds.
CPU load completed with 1 threads and 100000 iterations per thread. Execution time: 62.3586 seconds.
CPU load completed with 1 threads and 100000 iterations per thread. Execution time: 62.4095 seconds.
CPU load completed with 1 threads and 100000 iterations per thread. Execution time: 62.6968 seconds.
CPU load completed with 1 threads and 100000 iterations per thread. Execution time: 62.7856 seconds.
CPU load completed with 1 threads and 100000 iterations per thread. Execution time: 62.788 seconds.
CPU load completed with 1 threads and 100000 iterations per thread. Execution time: 62.7872 seconds.
CPU load completed with 1 threads and 100000 iterations per thread. Execution time: 62.8079 seconds.
CPU load completed with 1 threads and 100000 iterations per thread. Execution time: 62.9699 seconds.
CPU load completed with 1 threads and 100000 iterations per thread. Execution time: 62.976 seconds.
```

```
real    1m2.984s
user    5m32.895s
sys     0m41.750s
```

```

0[|||||]100.0% 3[|||||]100.0% 812M/3.83G] Tasks: 118, 249 thr, 91 kthr; 6 running
1[|||||]100.0% 4[|||||]100.0%
2[|||||]100.0% 5[|||||]100.0%
Mem[|||||]100.0% 0K/976M] Load average: 5.30 4.16 3.74
Swp[ Uptime: 02:03:38

```

| Main | I/O | PID | USER | PRI | NI | VIRT | RES | SHR | S | CPU% | MEM% | TIME+ | Command |
|------|-----|------|--------|-----|----|-------|------|------|---|------|------|---------|---------------------------------------|
| | | 3820 | debian | 20 | 0 | 78976 | 1668 | 1500 | R | 51.7 | 0.0 | 0:03.18 | ./load_tester ema-sort-int 1 100000 |
| | | 3809 | debian | 20 | 0 | 78976 | 1668 | 1500 | S | 51.0 | 0.0 | 0:02.96 | ./load_tester ema-sort-int 1 100000 |
| | | 3812 | debian | 20 | 0 | 78976 | 1668 | 1500 | S | 51.0 | 0.0 | 0:03.18 | ./load_tester ema-sort-int 1 100000 |
| | | 3813 | debian | 20 | 0 | 78976 | 1668 | 1500 | S | 51.0 | 0.0 | 0:02.85 | ./load_tester ema-sort-int 1 100000 |
| | | 3822 | debian | 20 | 0 | 78976 | 1668 | 1500 | R | 51.0 | 0.0 | 0:02.85 | ./load_tester ema-sort-int 1 100000 |
| | | 3803 | debian | 20 | 0 | 78976 | 1672 | 1500 | S | 50.3 | 0.0 | 0:02.96 | ./load_tester ema-sort-int 1 100000 |
| | | 3805 | debian | 20 | 0 | 78976 | 1668 | 1500 | S | 50.3 | 0.0 | 0:02.86 | ./load_tester ema-sort-int 1 100000 |
| | | 3806 | debian | 20 | 0 | 78976 | 1668 | 1500 | S | 50.3 | 0.0 | 0:02.87 | ./load_tester ema-sort-int 1 100000 |
| | | 3807 | debian | 20 | 0 | 78976 | 1668 | 1500 | S | 50.3 | 0.0 | 0:02.93 | ./load_tester ema-sort-int 1 100000 |
| | | 3808 | debian | 20 | 0 | 78976 | 1660 | 1492 | S | 50.3 | 0.0 | 0:02.94 | ./load_tester ema-sort-int 1 100000 |
| | | 3814 | debian | 20 | 0 | 78976 | 1668 | 1500 | S | 50.3 | 0.0 | 0:03.07 | ./load_tester ema-sort-int 1 100000 |
| | | 3816 | debian | 20 | 0 | 78976 | 1672 | 1500 | R | 50.3 | 0.0 | 0:02.96 | ./load_tester ema-sort-int 1 100000 |
| | | 3819 | debian | 20 | 0 | 78976 | 1668 | 1500 | R | 50.3 | 0.0 | 0:02.95 | ./load_tester ema-sort-int 1 100000 |
| | | 3821 | debian | 20 | 0 | 78976 | 1660 | 1492 | R | 50.3 | 0.0 | 0:02.94 | ./load_tester ema-sort-int 1 100000 |
| | | 3823 | debian | 20 | 0 | 78976 | 1664 | 1496 | R | 50.3 | 0.0 | 0:02.93 | ./load_tester ema-sort-int 1 100000 |
| | | 3824 | debian | 20 | 0 | 78976 | 1668 | 1500 | R | 50.3 | 0.0 | 0:03.07 | ./load_tester ema-sort-int 1 100000 |
| | | 3825 | debian | 20 | 0 | 78976 | 1668 | 1500 | R | 50.3 | 0.0 | 0:02.93 | ./load_tester ema-sort-int 1 100000 |
| | | 3802 | debian | 20 | 0 | 78976 | 1668 | 1500 | S | 49.7 | 0.0 | 0:02.90 | ./load_tester ema-sort-int 1 100000 |
| | | 3804 | debian | 20 | 0 | 78976 | 1668 | 1500 | S | 49.7 | 0.0 | 0:02.83 | ./load_tester ema-sort-int 1 100000 |
| | | 3810 | debian | 20 | 0 | 78976 | 1664 | 1496 | S | 49.7 | 0.0 | 0:02.93 | ./load_tester ema-sort-int 1 100000 |
| | | 3811 | debian | 20 | 0 | 78976 | 1668 | 1500 | R | 49.7 | 0.0 | 0:02.90 | ./load_tester ema-sort-int 1 100000 |
| | | 3815 | debian | 20 | 0 | 78976 | 1668 | 1500 | R | 49.7 | 0.0 | 0:02.83 | ./load_tester ema-sort-int 1 100000 |
| | | 3817 | debian | 20 | 0 | 78976 | 1668 | 1500 | R | 49.7 | 0.0 | 0:02.87 | ./load_tester ema-sort-int 1 100000 |
| | | 3818 | debian | 20 | 0 | 78976 | 1668 | 1500 | R | 49.7 | 0.0 | 0:02.86 | ./load_tester ema-sort-int 1 100000 |
| | | 3801 | debian | 20 | 0 | 5136 | 2632 | 2440 | S | 0.0 | 0.1 | 0:00.00 | ./parallels 12 ./load_tester ema-sort |

▼ command

```

1 sudo perf stat -e task-clock,context-switches,cpu-migrations,page-faults,cycles,instructions ./parallels
24 ./load_tester ema-sort-int 1 1000000

```

0[|||||100.0%] 3[|||||100.0%]
 1[|||||99.4%] 4[|||||100.0%]
 2[|||||100.0%] 5[|||||100.0%]
 Mem[|||||100.0%] Tasks: 134, 263 thr, 91 kthr; 6 running
 Swp[0K/976M] Load average: 10.00 5.80 4.35
 Uptime: 02:04:50

| Main | I/O | PID | USER | PRI | NI | VIRT | RES | SHR | S | CPU% | MEM% | TIME+ | Command |
|------|-----|------|------|-----|----|-------|------|------|---|------|------|---------|--------------------------------------|
| | | 3835 | root | 20 | 0 | 78976 | 1668 | 1500 | S | 27.5 | 0.0 | 0:01.44 | ./load_tester ema-sort-int 1 1000000 |
| | | 3843 | root | 20 | 0 | 78976 | 1668 | 1500 | S | 27.5 | 0.0 | 0:01.54 | ./load_tester ema-sort-int 1 1000000 |
| | | 3846 | root | 20 | 0 | 78976 | 1668 | 1500 | R | 27.5 | 0.0 | 0:01.44 | ./load_tester ema-sort-int 1 1000000 |
| | | 3864 | root | 20 | 0 | 78976 | 1664 | 1496 | R | 27.5 | 0.0 | 0:01.46 | ./load_tester ema-sort-int 1 1000000 |
| | | 3842 | root | 20 | 0 | 78976 | 1664 | 1496 | S | 26.9 | 0.0 | 0:01.46 | ./load_tester ema-sort-int 1 1000000 |
| | | 3860 | root | 20 | 0 | 78976 | 1668 | 1500 | S | 26.9 | 0.0 | 0:01.46 | ./load_tester ema-sort-int 1 1000000 |
| | | 3866 | root | 20 | 0 | 78976 | 1668 | 1500 | R | 26.9 | 0.0 | 0:01.54 | ./load_tester ema-sort-int 1 1000000 |
| | | 3879 | root | 20 | 0 | 78976 | 1668 | 1500 | R | 26.9 | 0.0 | 0:01.46 | ./load_tester ema-sort-int 1 1000000 |
| | | 3857 | root | 20 | 0 | 78976 | 1668 | 1500 | S | 26.2 | 0.0 | 0:01.56 | ./load_tester ema-sort-int 1 1000000 |
| | | 3873 | root | 20 | 0 | 78976 | 1668 | 1500 | R | 26.2 | 0.0 | 0:01.56 | ./load_tester ema-sort-int 1 1000000 |
| | | 3836 | root | 20 | 0 | 78976 | 1668 | 1500 | S | 24.9 | 0.0 | 0:01.46 | ./load_tester ema-sort-int 1 1000000 |
| | | 3837 | root | 20 | 0 | 78976 | 1668 | 1500 | S | 24.9 | 0.0 | 0:01.44 | ./load_tester ema-sort-int 1 1000000 |
| | | 3841 | root | 20 | 0 | 78976 | 1668 | 1500 | S | 24.9 | 0.0 | 0:01.42 | ./load_tester ema-sort-int 1 1000000 |
| | | 3847 | root | 20 | 0 | 78976 | 1668 | 1500 | R | 24.9 | 0.0 | 0:01.46 | ./load_tester ema-sort-int 1 1000000 |
| | | 3850 | root | 20 | 0 | 78976 | 1668 | 1500 | S | 24.9 | 0.0 | 0:01.50 | ./load_tester ema-sort-int 1 1000000 |
| | | 3853 | root | 20 | 0 | 78976 | 1668 | 1500 | R | 24.9 | 0.0 | 0:01.44 | ./load_tester ema-sort-int 1 1000000 |
| | | 3863 | root | 20 | 0 | 78976 | 1668 | 1500 | R | 24.9 | 0.0 | 0:01.42 | ./load_tester ema-sort-int 1 1000000 |
| | | 3840 | root | 20 | 0 | 78976 | 1668 | 1500 | S | 24.2 | 0.0 | 0:01.69 | ./load_tester ema-sort-int 1 1000000 |
| | | 3852 | root | 20 | 0 | 78976 | 1668 | 1500 | S | 24.2 | 0.0 | 0:01.56 | ./load_tester ema-sort-int 1 1000000 |
| | | 3854 | root | 20 | 0 | 78976 | 1668 | 1500 | S | 24.2 | 0.0 | 0:01.34 | ./load_tester ema-sort-int 1 1000000 |
| | | 3861 | root | 20 | 0 | 78976 | 1668 | 1500 | S | 24.2 | 0.0 | 0:01.44 | ./load_tester ema-sort-int 1 1000000 |
| | | 3862 | root | 20 | 0 | 78976 | 1668 | 1500 | S | 24.2 | 0.0 | 0:01.51 | ./load_tester ema-sort-int 1 1000000 |
| | | 3865 | root | 20 | 0 | 78976 | 1668 | 1500 | S | 24.2 | 0.0 | 0:01.39 | ./load_tester ema-sort-int 1 1000000 |
| | | 3868 | root | 20 | 0 | 78976 | 1668 | 1500 | R | 24.2 | 0.0 | 0:01.69 | ./load_tester ema-sort-int 1 1000000 |
| | | 3869 | root | 20 | 0 | 78976 | 1668 | 1500 | R | 24.2 | 0.0 | 0:01.56 | ./load_tester ema-sort-int 1 1000000 |
| | | 3870 | root | 20 | 0 | 78976 | 1668 | 1500 | R | 24.2 | 0.0 | 0:01.49 | ./load_tester ema-sort-int 1 1000000 |
| | | 3872 | root | 20 | 0 | 78976 | 1668 | 1500 | R | 24.2 | 0.0 | 0:01.48 | ./load_tester ema-sort-int 1 1000000 |
| | | 3876 | root | 20 | 0 | 78976 | 1668 | 1500 | R | 24.2 | 0.0 | 0:01.34 | ./load_tester ema-sort-int 1 1000000 |
| | | 3877 | root | 20 | 0 | 78976 | 1656 | 1488 | R | 24.2 | 0.0 | 0:01.34 | ./load_tester ema-sort-int 1 1000000 |
| | | 3880 | root | 20 | 0 | 78976 | 1668 | 1500 | R | 24.2 | 0.0 | 0:01.39 | ./load_tester ema-sort-int 1 1000000 |
| | | 3881 | root | 20 | 0 | 78976 | 1668 | 1500 | R | 24.2 | 0.0 | 0:01.44 | ./load_tester ema-sort-int 1 1000000 |
| | | 3882 | root | 20 | 0 | 78976 | 1668 | 1500 | R | 24.2 | 0.0 | 0:01.51 | ./load_tester ema-sort-int 1 1000000 |
| | | 3838 | root | 20 | 0 | 78976 | 1656 | 1488 | S | 23.6 | 0.0 | 0:01.49 | ./load_tester ema-sort-int 1 1000000 |
| | | 3845 | root | 20 | 0 | 78976 | 1664 | 1496 | S | 23.6 | 0.0 | 0:01.35 | ./load_tester ema-sort-int 1 1000000 |

```
debian@debian:~/Documents/shell$ sudo perf stat -e task-clock,context-switches,cpu-migrations,page-faults,cycles,instructions ./parallels 24 ./load_tester ema-sort-int 1 1000000
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 1254.97 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 1255.3 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 1256.36 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 1257.17 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 1258.46 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 1258.97 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 1259.36 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 1259.34 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 1259.46 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 1259.45 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 1259.56 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 1260.19 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 1260.28 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 1260.45 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 1260.69 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 1260.71 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 1260.96 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 1261.02 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 1261 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 1261.1 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 1261.12 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 1261.37 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 1261.47 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 1261.95 seconds.
```

```
Performance counter stats for './parallels 24 ./load_tester ema-sort-int 1 1000000':
```

| | | |
|-------------------|------------------|-----------------------|
| 7,520,694.03 msec | task-clock | # 5.960 CPUs utilized |
| 1,545,249 | context-switches | # 205.466 /sec |
| 11,951 | cpu-migrations | # 1.589 /sec |
| 4,399 | page-faults | # 0.585 /sec |
| <not supported> | cycles | |
| <not supported> | instructions | |

```
1261.953319535 seconds time elapsed
```

```
6685.093246000 seconds user
828.150057000 seconds sys
```

```

debian@debian:~/Documents/shell$ sudo perf stat -e task-clock,context-switches,cpu-migrations,page-faults,cycles,instructions ./parallels 24 ./load_tester ema-sort-int 1 1000000
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 1254.97 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 1255.3 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 1256.36 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 1257.17 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 1258.46 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 1258.97 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 1259.36 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 1259.34 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 1259.46 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 1259.45 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 1259.56 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 1260.19 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 1260.28 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 1260.45 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 1260.69 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 1260.71 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 1260.96 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 1261.02 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 1261 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 1261.1 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 1261.12 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 1261.37 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 1261.47 seconds.
CPU load completed with 1 threads and 1000000 iterations per thread. Execution time: 1261.95 seconds.

Performance counter stats for './parallels 24 ./load_tester ema-sort-int 1 1000000':

```

| | | |
|-------------------|------------------|-----------------------|
| 7,520,694.03 msec | task-clock | # 5.960 CPUs utilized |
| 1,545,249 | context-switches | # 205.466 /sec |
| 11,951 | cpu-migrations | # 1.589 /sec |
| 4,399 | page-faults | # 0.585 /sec |
| <not supported> | cycles | |
| <not supported> | instructions | |

1261.953319535 seconds time elapsed

6685.093246000 seconds user
828.150057000 seconds sys

5. **Объедините нагрузчики в одну программу с потоками, чтобы один нагрузчик эффективно использовал все ядра системы. Как изменились времена выполнения при том же объеме вычислений? Запустите одну, две, три такие программы.**

▼ command

```
1 time ./parallels 1 ./load_tester bin-search 3 1000000
```

```

debian@debian:~/Documents/shell$ time ./parallels 1 ./load_tester bin-search 3 1000000
CPU load completed with 3 threads and 1000000 iterations per thread. Execution time: 19.9371 seconds.

real    0m19.942s
user    0m59.706s
sys     0m0.009s

```

▼ command

```
1 time ./parallels 3 ./load_tester bin-search 3 1000000
```

```

debian@debian:~/Documents/shell$ time ./parallels 2 ./load_tester bin-search 3 1000000
CPU load completed with 3 threads and 1000000 iterations per thread. Execution time: 24.131 seconds.
CPU load completed with 3 threads and 1000000 iterations per thread. Execution time: 24.4393 seconds.

real    0m24.445s
user    2m23.854s
sys     0m0.016s

```

▼ command

```
1 time ./parallels 1 ./load_tester ema-sort-int 3 1000000

debian@debian:~/Documents/shell$ time ./parallels 1 ./load_tester ema-sort-int 3 1000000
CPU load completed with 3 threads and 1000000 iterations per thread. Execution time: 284.137 seconds.

real    4m44.151s
user    12m35.907s
sys     1m32.928s
-
debian@debian:~/Documents/shell$ time ./parallels 1 ./load_tester ema-sort-int 3 1000000
CPU load completed with 3 threads and 1000000 iterations per thread. Execution time: 284.137 seconds.

real    4m44.151s
user    12m35.907s
sys     1m32.928s
-
▼ command

1 time ./parallels 3 ./load_tester ema-sort-int 3 1000000

debian@debian:~/Documents/shell$ time ./parallels 3 ./load_tester ema-sort-int 3 1000000
CPU load completed with 3 threads and 1000000 iterations per thread. Execution time: 478.748 seconds.
CPU load completed with 3 threads and 1000000 iterations per thread. Execution time: 482.502 seconds.
CPU load completed with 3 threads and 1000000 iterations per thread. Execution time: 487.23 seconds.

real    8m7.245s
user    42m7.126s
sys     5m43.222s
debian@debian:~/Documents/shell$ █
```

6. Включите опции агрессивной оптимизации компилятора. Как изменились времена выполнения? Насколько сократилось реальное время работы нагрузчика?

```
▼ command

1 time ./parallels 1 ./load_tester_opt bin-search 3 1000000

debian@debian:~/Documents/shell$ time ./parallels 1 ./load_tester_opt bin-search 3 1000000
CPU load completed with 3 threads and 1000000 iterations per thread. Execution time: 1.67561 seconds.

real    0m1.681s
user    0m5.023s
sys     0m0.000s
-
▼ command

1 time ./parallels 1 ./load_tester_opt ema-sort-int 3 1000000

debian@debian:~/Documents/shell$ time ./parallels 1 ./load_tester_opt ema-sort-int 3 1000000
CPU load completed with 3 threads and 1000000 iterations per thread. Execution time: 89.2437 seconds.

real    1m29.250s
user    2m46.198s
sys     1m36.722s
```

Вывод

- В ходе выполнения лабораторной работы была разработана оболочка shell и программы-нагрузчики на языке C++. Для сбора метрик программ-нагрузчиков использовались утилиты Linux.