# workshop优化

fork

优化

### fork

```
git clone https://github.com/xingfeng2510/workshop.git
1
2
    cd workshop
3
4
5
    ./workshop
ubuntu@VM-0-11-ubuntu:~/workshop$ sudo time ./workshop
Matrix multiply iteration 1: cost 35.525 seconds
Matrix multiply iteration 2: cost 36.618 seconds
Matrix multiply iteration 3: cost 33.435 seconds
Matrix multiply iteration 4: cost 33.503 seconds
Matrix multiply iteration 5: cost 33.881 seconds
Matrix multiply iteration 6: cost 34.330 seconds
Matrix multiply iteration 7: cost 34.003 seconds
Command terminated by signal 9
535.10user 2.40system 4:34.00elapsed 196%CPU (0avgtext+0avgdata 263356maxresident)k
```

原始程序在第7次迭代后因内存超限被 signal 9(SIGKILL) 终止。平均在34.4s

Oinputs+Ooutputs (Omajor+360406minor)pagefaults Oswaps

## 优化

1、 main.c 中 Multiplyonce 函数调用了 ParallelMultiply ,后者通过多线程执行 mul函数。

矩阵乘法本身是三重循环、是计算密集型。

ubuntu@VM-0-11-ubuntu:~/workshop\$

- 循环顺序: 原代码中循环顺序是 i-j-k ,即外层循环是行 i ,中层是列 j ,内层是累加 k 。这种顺序可能导致对内存的非连续访问,降低缓存效率。
  - 额外操作:每次计算完 c[i][i] 后调用 vector\_append ,但这个向量未被使用。
  - 未初始化内存: c 数组在计算前未清零。

```
mul.c
 1 void mul(int msize, int tidx, int numt, Vector *vec, TYPE a[][NUM], TYPE b
     [][NUM], TYPE c[][NUM], TYPE t[][NUM]) {
 2
        int i, j, k;
        for (i = tidx; i < msize; i += numt) {</pre>
            // 初始化c[i][i]为0
 5
            for (j = 0; j < msize; j++) {
6
                c[i][j] = 0.0;
 7
            // 调整循环顺序为i-k-i
8
9
            for (k = 0; k < msize; k++) {
10
                // 缓存a[i][k]减少重复访问
                TYPE a_{ik} = a[i][k];
11
                for (j = 0; j < msize; j++) {
12
13
                    c[i][i] += a ik * b[k][i];
14
15
16
17
```

3、在 thrmode1.c 的线程参数中,每个线程通过 vector\_create() 创建了 Vector 对象,但未调用 vector\_destroy() 释放内存。注:

```
thrmodel.c

1  // destroy vector here 33line
2  vector_destroy(par->vec); //34 line
```

4、-03 会开启 -02 所包含的所有优化,提高程序的运行性能。编译时间的增加不再考虑范围内。

```
    Makefile

1  # CFLAGS = -g -02 -fno-asm
2  CFLAGS = -g -03 -fno-asm
```

### -O3的优化结果在3.96 s 左右, -O2的优化结果在4.47 s 左右。

```
Matrix multiply iteration 90: cost 3.939 seconds Matrix multiply iteration 91: cost 3.956 seconds
                                                                                          Matrix multiply iteration 91: cost 4.470 seconds
Matrix multiply iteration 92: cost 3.936 seconds Matrix multiply iteration 93: cost 3.965 seconds
                                                                                          Matrix multiply iteration 92: cost 4.498 seconds
                                                                                          Matrix multiply iteration 93: cost 4.488 seconds
Matrix multiply iteration 94: cost 3.977 seconds
Matrix multiply iteration 95: cost 3.977 seconds
                                                                                          Matrix multiply iteration 94: cost 4.507 seconds
                                                                                          Matrix multiply iteration 95: cost 4.462 seconds
Matrix multiply iteration 96: cost 3.964 seconds
Matrix multiply iteration 97: cost 3.977 seconds
                                                                                          Matrix multiply iteration 96: cost 4.479 seconds
                                                                                          Matrix multiply iteration 97: cost 4.490 seconds
Matrix multiply iteration 98: cost 3.966 seconds Matrix multiply iteration 99: cost 3.966 seconds
                                                                                          Matrix multiply iteration 98: cost 4.474 seconds
Matrix multiply iteration 100: cost 3.957 seconds ubuntu@VM-0-11-ubuntu:~/workshop$
                                                                                          Matrix multiply iteration 99: cost 4.471 seconds
                                                                                          Matrix multiply iteration 100: cost 4.458 seconds
```

(a) O3 (b) O2

优化倍数分别是: 34.4/3.96≈8.67 34.4/4.47≈7.69

#### 附CPU利用率 htop

```
571M/3.28G] Uptime: 02:54:25
Swp
 PID USER
                   PRI NI VIRT RES SHR S CPU% MEM% TIME+ Command
66433 root
                           20 0 210M 99M 1988 S 192. 3.0 7:20.43 ./workshop
                           20 0 210M 99M 1988 R 16.0 3.0 0:00.24 ./workshop
68392 root
68393 root
                          20 0 210M 99M 1988 R 16.0 3.0 0:00.24 ./workshop
                          20 0 981M 74920 32456 S 1.3 2.2 1:12.64 /usr/local/qcloud/YunJing/YDEyes/YDService
                         20 0 618M 19528 5864 S 1.3 0.6 1:08.71 barad agent
 1464 root
                        20 0 981M 74920 32456 S 1.3 2.2 0:20.38 /usr/local/qcloud/YunJing/YDEyes/YDService
 2282 root
                        20 0 618M 19528 5864 S 1.3 0.6 0:16.50 barad_agent
                        20 0 46512 11504 3916 S 0.0 0.3 0:06.74 barad_agent
 1463 root
                          20 0 981M 74920 32456 S 0.0 2.2 0:05.45 /usr/local/gcloud/YunJing/YDEves/YDService
 2736 root
                          20 0 8292 4256 3292 R 0.0 0.1 0:00.06 htop
                           20 0 11.3G 96228 48856 S 0.0 2.8 0:12.98 /home/ubuntu/.vscode-server/cli/servers/Stable-ddc367ed5c8936efe395cffeec279b04ffd7db78/server/node /ho
 4355 ubuntu
                          20 0 31.3G 128M 54320 S 0.0 3.8 0:18.28 /home/ubuntu/.vscode-server/cli/servers/Stable-ddc367ed5c8936efe395cffeec279b04ffd7db78/server/node --dns-result-ord
                          20 0 981M 74920 32456 S 0.0 2.2 0:04.88 /usr/local/qcloud/YunJing/YDEyes/YDService
 2325 root
                           20 0 981M 74920 32456 S 0.0 2.2 0:04.36 /usr/local/qcloud/YunJing/YDEyes/YDService
 2323 root
                          20 0 981M 74920 32456 S 0.0 2.2 0:04.98 /usr/local/qcloud/YunJing/YDEyes/YDService
 3911 ubuntu 20 0 11.1G 71752 43504 S 0.0 2.1 0:10.31 /home/ubuntu/.vscode-server/cli/servers/Stable-ddc367ed5c8936efe395cffeec279b04ffd7db78/server/node /home/ubuntu/.vscode-server/cli/server/node /home/ubuntu/.vscode-server/cli/server/node /home/ubuntu/.vscode-server/cli/server/node /home/ubuntu/.vscode-server/cli/server/node /home/ubuntu/.vscode-server/cli/server/node /home/ubuntu/.vscode-server/cli/server/node /home/ubuntu/.vscode-server/cli/server/node /home/ubuntu/.vscode-server/node /home/ubuntu/.vscode-serv
                          908 root
```