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(Национальный Исследовательский Университет)
Институт №8 “Компьютерные науки и прикладная математика”
Кафедра №806 “Вычислительная математика и программирование”

Лабораторная работа №2 по курсу
«Операционные системы»

Группа: М80-206Б-22

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Преподаватель: Миронов Е.С.

Оценка: _____

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Постановка задачи

Вариант 4.

Отсортировать массив целых чисел при помощи TimSort.

Общий метод и алгоритм решения

Использованные системные вызовы:

- `pthread_create(_Nullable pthread_t *, const pthread_attr_t *, void * _Nullable (*)(void *), void *)` – создает поток.
- `pthread_join(pthread_t, void * _Nullable *)` – ждет завершения исполнения потока.

В TimSort использовать потоки можно в двух местах: на этапе разбиения на подмассивы длины `gap` для их сортировки вставками, на этапе слияния отсортированных подмассивов. В первом случае мы можем получить индексы начала и конца подмассивов и создавать потоки для их сортировки вставками, проблем с ними не возникнет, так как в области действия друг друга они работать не будут. А вот во втором случае может возникнуть проблема “гонки”, когда области действия могут “пересекаться”. Поэтому я реализовал только первый случай путем создания “конвейера” областей для сортировки, каждый поток “берет” свою область, сортирует и берет следующую, если она есть.

Код программы

main.c

```
#include <iostream>
#include <vector>
using namespace std;
const int RUN = 32;
vector<int> globe_vector(0);
pthread_mutex_t mut;
using partition = pair<int, int>;
typedef struct{
    int l;
    int m;
    int r;
}triple_partition;

// Utility function to print the Array
void printArray(vector<int>& arr)
{
    for (int elem : arr)
        printf("%d ", elem);
    printf("\n");
}
```

```
// This function sorts array from left index to to right index which is of size atmost RUN void* insertionSort(void* param)
```

```
void insertionSort(int left, int right)
```

```
{  
    for (int i = left + 1; i <= right; i++) {  
        int temp = globe_vector[i];  
        int j = i - 1;  
        while (j >= left && globe_vector[j] > temp) {  
            globe_vector[j + 1] = globe_vector[j];  
            j--;  
        }  
        globe_vector[j + 1] = temp;  
    }  
}
```

```
// for threading
```

```
void* inS(void* part)
```

```
{  
    int left = ((partition*)part)->first;  
    int right = ((partition*)part)->second;  
    insertionSort(left, right);  
    pthread_exit(0);  
    return 0;  
}
```

```
// Merge function merges the sorted runs
```

```
void merge(int l, int m, int r)
```

```
{  
    // Original array is broken in two parts left and right array  
    int len1 = m - l + 1, len2 = r - m;  
    int left[len1], right[len2];  
    for (int i = 0; i < len1; i++)  
        left[i] = globe_vector[l + i];  
    for (int i = 0; i < len2; i++)  
        right[i] = globe_vector[m + 1 + i];  
    int i = 0;  
    int j = 0;  
    int k = l;  
    // After comparing, we merge those two array in larger sub array  
    while (i < len1 && j < len2) {  
        if (left[i] <= right[j]) {  
            globe_vector[k] = left[i];  
            i++;  
        }  
        else {  
            globe_vector[k] = right[j];  
            j++;  
        }  
        k++;  
    }  
    // Copy remaining elements of left, if any  
    while (i < len1) {
```

```

        globe_vector[k] = left[i];
        k++;
        i++;
    }
    // Copy remaining element of right, if any
    while (j < len2) {
        globe_vector[k] = right[j];
        k++;
        j++;
    }
}

// Iterative Timsort function to sort the array[0...n-1] (similar to merge sort)
void timSort(int thread_count)
{
    int n = globe_vector.size();
    pthread_t tid[thread_count];
    // Partition individual subarrays of size RUN
    vector<partition> to_take(0);
    for (int i = 0; i < n; i += RUN){
        to_take.push_back(partition(i, min((i + RUN - 1), (n - 1))));
    }
    int n_parts = to_take.size();
    int ind = 0;
    while(n_parts > 0){
        for(int j = 0; j < min(n_parts, thread_count); ++j){
            pthread_create(&tid[j%thread_count], NULL, inS, &(to_take[ind%to_take.size()]));
            ++ind;
        }
        for(int k = 0; k < min(n_parts, thread_count); ++k){
            pthread_join(tid[k%thread_count], NULL);
        }
        n_parts-=thread_count;
    }

    // Start merging from size RUN (or 32). It will merge to form size 64, then 128, 256 and so on ....
    vector<triple_partition> to_merge;
    for (int size = RUN; size < n; size = 2 * size) {
        // pick starting point of left sub array. We are going to merge arr[left..left+size-1] and arr[left+size, left+2*size-1] After every merge, we increase left by 2*size
        for (int left = 0; left < n; left += 2 * size) {
            // Find ending point of left sub array mid+1 is starting point of right sub array
            int mid = left + size - 1;
            int right = min((left + 2 * size - 1), (n - 1));
            // merge sub array arr[left.....mid] & arr[mid+1.....right]
            if (mid < right){
                merge(left, mid, right);
            }
        }
    }
}

int main(int argc, char* argv[])

```

```

{
    // check correct key
    if (argc != 2) {
        perror("\nError: no threads to use\n");
        exit(EXIT_FAILURE);
    }
    if(atoi(argv[1]) < 1 ){
        perror("\nError: Wrong count (try 4>='integer'>=1)\n");
        exit(EXIT_FAILURE);
    }
    const int thread_count = atoi(argv[1]);
    // Input array
    int tmp;
    printf("Type your array: ");
    while(scanf("%d", &tmp) > 0){
        globe_vector.push_back(tmp);
    }
    // Function Call
    timSort(thread_count);
    // Results
    printf("\nAfter Sorting globe Array is: ");
    printArray(globe_vector);
    printf("\nArray size was %d\n", globe_vector.size());
    return 0;
}

```

Протокол работы программы

Тестирование:

mishazhadnov@McB-airmi scr % ./prog 3 <bad.txt

Type your array:

After Sorting Array is: 1 1 1 1 1 1 1 7 7 7 7 7 9 9 9 9 9 23 23 23 23 23 31 31
31 49 49 49 50 50 50 50 50 50 77 77 77 77 77 80 92 92 101 101 101 127 127 127
127 277 277 305 305 404 404 404 500 500 500 500 5000 7007 7007 7009 7079 7079
7079 7079

Array size was 68

Расчеты производились для массива из 2 096 085 элементов:

Кол-во потоков	Время (мс)	Ускорение	Эффективность
1	3 345	1	1
2	2 932	1.14	0.57
3	2 682	1.25	0.41
4	2 663	1.26	0.31

Dtrace (аналог strace):

mishazhadnov@McB-airmi scr % sudo dtruss ./prog 3 <bad.txt

dtrace: system integrity protection is on, some features will not be available

SYSCALL(args) = return

Type your array:

After Sorting Array is: 1 1 1 1 1 1 1 7 7 7 7 7 9 9 9 9 9 23 23 23 23 31 31 31 49 49 49 50 50 50 50 50 50 77 77 77 77 77 80 92 92 101 101 101 127 127
127 127 277 277 305 305 404 404 404 500 500 500 500 5000 7007 7007 7009 7079 7079 7079 7079

Array size was 68

munmap(0x11622E000, 0xA0000) = 0 0

munmap(0x1162CE000, 0x8000) = 0 0

munmap(0x1162D6000, 0x4000) = 0 0

munmap(0x1162DA000, 0x4000) = 0 0

munmap(0x1162DE000, 0x58000) = 0 0

open("./0", 0x100000, 0x0) = 3 0

fcntl(0x3, 0x32, 0x7FF7B822D290) = 0 0

close(0x3) = 0 0

fsgetpath(0x7FF7B822D2A0, 0x400, 0x7FF7B822D288) = 56 0

fsgetpath(0x7FF7B822D2A0, 0x400, 0x7FF7B822D288) = 14 0

```

csctl(0x0, 0x7FF7B822D6AC, 0x4)          = -1 1

__mac_syscall(0x7FF808646E3B, 0x2, 0x7FF7B822D510)      = 0 0

csctl(0x0, 0x7FF7B822D6BC, 0x4)          = -1 1

__mac_syscall(0x7FF808643DC6, 0x5A, 0x7FF7B822D650)      = 0 0

dtrace: error on enabled probe ID 1741 (ID 573: syscall::sysctl:return): invalid kernel access in action #10 at DIF offset 28

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dtrace: error on enabled probe ID 1741 (ID 573: syscall::sysctl:return): invalid kernel access in action #10 at DIF offset 28

open("/^0", 0x20100000, 0x0)              = 3 0

openat(0x3, "System/Cryptexes/OS^0", 0x100000, 0x0)      = 4 0

dup(0x4, 0x0, 0x0)                       = 5 0

fstatat64(0x4, 0x7FF7B822C3F1, 0x7FF7B822C7F0)          = 0 0

openat(0x4, "System/Library/dyld/^0", 0x100000, 0x0)    = 6 0

fcntl(0x6, 0x32, 0x7FF7B822C480)           = 0 0

dup(0x6, 0x0, 0x0)                       = 7 0

dup(0x5, 0x0, 0x0)                       = 8 0

close(0x3)                               = 0 0

close(0x5)                               = 0 0

close(0x4)                               = 0 0

close(0x6)                               = 0 0

shared_region_check_np(0x7FF7B822CD68, 0x0, 0x0)        = 0 0

fsgetpath(0x7FF7B822D2D0, 0x400, 0x7FF7B822D208)        = 83 0

fcntl(0x8, 0x32, 0x7FF7B822D2D0)          = 0 0

close(0x8)                               = 0 0

close(0x7)                               = 0 0

getfsstat64(0x0, 0x0, 0x2)                = 7 0

getfsstat64(0x108202AA0, 0x3B48, 0x2)      = 7 0

getattrlist("/^0", 0x7FF7B822D210, 0x7FF7B822D180)      = 0 0

stat64("/System/Volumes/Preboot/Cryptexes/OS/System/Library/dyld/dyld_shared_cache_x86_64h/0", 0x7FF7B822D548, 0x0) = 0 0

dtrace: error on enabled probe ID 1690 (ID 845: syscall::stat64:return): invalid address (0x0) in action #11 at DIF offset 12

stat64("/Users/mishazhadnov/Desktop/wD/OS_labs_3t/lab2/scr/prog/0", 0x7FF7B822C9E0, 0x0) = 0 0

open("/Users/mishazhadnov/Desktop/wD/OS_labs_3t/lab2/scr/prog/0", 0x0, 0x0)          = 3 0

```

```
mmap(0x0, 0x15838, 0x1, 0x40002, 0x3, 0x0)      = 0x107CEA000 0

fcntl(0x3, 0x32, 0x7FF7B822CAf0)                = 0 0

close(0x3)                                       = 0 0

munmap(0x107CEA000, 0x15838)                    = 0 0

stat64("/Users/mishazhadnov/Desktop/wD/OS_labs_3t/lab2/scr/prog\0", 0x7FF7B822CF40, 0x0)    = 0 0

open("/usr/local/opt/gcc/lib/gcc/current/libstdc++.6.dylib\0", 0x0, 0x0)                = 3 0

fcntl(0x3, 0x32, 0x7FF7B822C390)                = 0 0

close(0x3)                                       = 0 0

stat64("/usr/local/opt/gcc/lib/gcc/current/libstdc++.6.dylib\0", 0x7FF7B822BF50, 0x0)      = 0 0

stat64("/usr/local/opt/gcc/lib/gcc/current/libstdc++.6.dylib\0", 0x7FF7B822B9B0, 0x0)      = 0 0

open("/usr/local/opt/gcc/lib/gcc/current/libstdc++.6.dylib\0", 0x0, 0x0)                = 3 0

mmap(0x0, 0x3C2770, 0x1, 0x40002, 0x3, 0x0)      = 0x108241000 0

fcntl(0x3, 0x32, 0x7FF7B822BAC0)                = 0 0

close(0x3)                                       = 0 0

open("/usr/local/Cellar/gcc/13.2.0/lib/gcc/current/libstdc++.6.dylib\0", 0x0, 0x0)        = 3 0

fcntl(0x3, 0x62, 0x7FF7B822B778)                = 0 0

mmap(0x108604000, 0x1E4000, 0x5, 0x40012, 0x3, 0x0) = 0x108604000 0

mmap(0x1087E8000, 0xC000, 0x3, 0x40012, 0x3, 0x1E4000) = 0x1087E8000 0

mmap(0x1087F4000, 0xC000, 0x3, 0x40012, 0x3, 0x1F0000) = 0x1087F4000 0

mmap(0x108804000, 0x1C8000, 0x1, 0x40012, 0x3, 0x1FC000) = 0x108804000 0

close(0x3)                                       = 0 0

munmap(0x108241000, 0x3C2770)                    = 0 0

open("/usr/local/opt/gcc/lib/gcc/current/libgcc_s.1.1.dylib\0", 0x0, 0x0)              = 3 0

fcntl(0x3, 0x32, 0x7FF7B822C390)                = 0 0

close(0x3)                                       = 0 0

stat64("/usr/local/opt/gcc/lib/gcc/current/libgcc_s.1.1.dylib\0", 0x7FF7B822BF50, 0x0)    = 0 0

stat64("/usr/local/opt/gcc/lib/gcc/current/libgcc_s.1.1.dylib\0", 0x7FF7B822B9B0, 0x0)    = 0 0

open("/usr/local/opt/gcc/lib/gcc/current/libgcc_s.1.1.dylib\0", 0x0, 0x0)              = 3 0

mmap(0x0, 0x2D310, 0x1, 0x40002, 0x3, 0x0)      = 0x108101000 0

fcntl(0x3, 0x32, 0x7FF7B822BAC0)                = 0 0

close(0x3)                                       = 0 0

open("/usr/local/Cellar/gcc/13.2.0/lib/gcc/current/libgcc_s.1.1.dylib\0", 0x0, 0x0)      = 3 0
```



```

fcntl(0x3, 0x62, 0x7FF7B822B798)          = 0 0

mmap(0x10812F000, 0x1C000, 0x5, 0x40012, 0x3, 0x4000)    = 0x10812F000 0

mmap(0x10814B000, 0x4000, 0x3, 0x40012, 0x3, 0x20000)    = 0x10814B000 0

mmap(0x10814F000, 0xC000, 0x1, 0x40012, 0x3, 0x24000)    = 0x10814F000 0

close(0x3)          = 0 0

munmap(0x108101000, 0x2D310)              = 0 0

stat64("/usr/lib/libSystem.B.dylib\0", 0x7FF7B822BF50, 0x0)    = -1 2

stat64("/System/Volumes/Preboot/Cryptexes/OS/usr/lib/libSystem.B.dylib\0", 0x7FF7B822BF00, 0x0)    = -1 2

stat64("/usr/lib/libSystem.B.dylib\0", 0x7FF7B822BF50, 0x0)    = -1 2

stat64("/usr/lib/libobjc.A.dylib\0", 0x7FF7B8229BA0, 0x0)      = -1 2

stat64("/System/Volumes/Preboot/Cryptexes/OS/usr/lib/libobjc.A.dylib\0", 0x7FF7B8229B50, 0x0)    = -1 2

stat64("/usr/lib/libobjc.A.dylib\0", 0x7FF7B8229BA0, 0x0)      = -1 2

stat64("/usr/lib/system/libsystem_blocks.dylib\0", 0x7FF7B8229BA0, 0x0)    = -1 2

stat64("/System/Volumes/Preboot/Cryptexes/OS/usr/lib/system/libsystem_blocks.dylib\0", 0x7FF7B8229B40, 0x0)    = -1 2

stat64("/usr/lib/system/libsystem_blocks.dylib\0", 0x7FF7B8229BA0, 0x0)    = -1 2

stat64("/usr/lib/system/libxpc.dylib\0", 0x7FF7B8229BA0, 0x0)  = -1 2

stat64("/System/Volumes/Preboot/Cryptexes/OS/usr/lib/system/libxpc.dylib\0", 0x7FF7B8229B50, 0x0)    = -1 2

stat64("/usr/lib/system/libxpc.dylib\0", 0x7FF7B8229BA0, 0x0)  = -1 2

stat64("/usr/lib/system/libsystem_trace.dylib\0", 0x7FF7B8229BA0, 0x0)    = -1 2

stat64("/System/Volumes/Preboot/Cryptexes/OS/usr/lib/system/libsystem_trace.dylib\0", 0x7FF7B8229B40, 0x0)    = -1 2

stat64("/usr/lib/system/libsystem_trace.dylib\0", 0x7FF7B8229BA0, 0x0)    = -1 2

stat64("/usr/lib/system/libcorecrypto.dylib\0", 0x7FF7B8229BA0, 0x0)    = -1 2

stat64("/System/Volumes/Preboot/Cryptexes/OS/usr/lib/system/libcorecrypto.dylib\0", 0x7FF7B8229B50, 0x0)    = -1 2

stat64("/usr/lib/system/libcorecrypto.dylib\0", 0x7FF7B8229BA0, 0x0)    = -1 2

stat64("/usr/lib/system/libsystem_malloc.dylib\0", 0x7FF7B8229BA0, 0x0)    = -1 2

stat64("/System/Volumes/Preboot/Cryptexes/OS/usr/lib/system/libsystem_malloc.dylib\0", 0x7FF7B8229B40, 0x0)    = -1 2

stat64("/usr/lib/system/libsystem_malloc.dylib\0", 0x7FF7B8229BA0, 0x0)    = -1 2

stat64("/usr/lib/system/libdispatch.dylib\0", 0x7FF7B8229BA0, 0x0)    = -1 2

stat64("/System/Volumes/Preboot/Cryptexes/OS/usr/lib/system/libdispatch.dylib\0", 0x7FF7B8229B50, 0x0)    = -1 2

stat64("/usr/lib/system/libdispatch.dylib\0", 0x7FF7B8229BA0, 0x0)    = -1 2

stat64("/usr/lib/system/libsystem_featureflags.dylib\0", 0x7FF7B8229BA0, 0x0)    = -1 2

stat64("/System/Volumes/Preboot/Cryptexes/OS/usr/lib/system/libsystem_featureflags.dylib\0", 0x7FF7B8229B40, 0x0)    = -1 2

```

stat64("/usr/lib/system/libsystem_featureflags.dylib\0", 0x7FF7B8229BA0, 0x0) = -1 2

stat64("/usr/lib/system/libsystem_c.dylib\0", 0x7FF7B8229BA0, 0x0) = -1 2

stat64("/System/Volumes/Preboot/Cryptexes/OS/usr/lib/system/libsystem_c.dylib\0", 0x7FF7B8229B50, 0x0) = -1 2

stat64("/usr/lib/system/libsystem_c.dylib\0", 0x7FF7B8229BA0, 0x0) = -1 2

stat64("/usr/lib/libc++.1.dylib\0", 0x7FF7B8229BA0, 0x0) = -1 2

stat64("/System/Volumes/Preboot/Cryptexes/OS/usr/lib/libc++.1.dylib\0", 0x7FF7B8229B50, 0x0) = -1 2

stat64("/usr/lib/libc++.1.dylib\0", 0x7FF7B8229BA0, 0x0) = -1 2

stat64("/usr/lib/libc++abi.dylib\0", 0x7FF7B8229BA0, 0x0) = -1 2

stat64("/System/Volumes/Preboot/Cryptexes/OS/usr/lib/libc++abi.dylib\0", 0x7FF7B8229B50, 0x0) = -1 2

stat64("/usr/lib/libc++abi.dylib\0", 0x7FF7B8229BA0, 0x0) = -1 2

stat64("/usr/lib/system/libdyld.dylib\0", 0x7FF7B8229BA0, 0x0) = -1 2

stat64("/System/Volumes/Preboot/Cryptexes/OS/usr/lib/system/libdyld.dylib\0", 0x7FF7B8229B50, 0x0) = -1 2

stat64("/usr/lib/system/libdyld.dylib\0", 0x7FF7B8229BA0, 0x0) = -1 2

stat64("/usr/lib/system/libsystem_info.dylib\0", 0x7FF7B8229BA0, 0x0) = -1 2

stat64("/System/Volumes/Preboot/Cryptexes/OS/usr/lib/system/libsystem_info.dylib\0", 0x7FF7B8229B50, 0x0) = -1 2

stat64("/usr/lib/system/libsystem_info.dylib\0", 0x7FF7B8229BA0, 0x0) = -1 2

stat64("/usr/lib/system/libsystem_darwin.dylib\0", 0x7FF7B8229BA0, 0x0) = -1 2

stat64("/System/Volumes/Preboot/Cryptexes/OS/usr/lib/system/libsystem_darwin.dylib\0", 0x7FF7B8229B40, 0x0) = -1 2

stat64("/usr/lib/system/libsystem_darwin.dylib\0", 0x7FF7B8229BA0, 0x0) = -1 2

stat64("/usr/lib/system/libsystem_notify.dylib\0", 0x7FF7B8229BA0, 0x0) = -1 2

stat64("/System/Volumes/Preboot/Cryptexes/OS/usr/lib/system/libsystem_notify.dylib\0", 0x7FF7B8229B40, 0x0) = -1 2

stat64("/usr/lib/system/libsystem_notify.dylib\0", 0x7FF7B8229BA0, 0x0) = -1 2

stat64("/usr/lib/system/libsystem_networkextension.dylib\0", 0x7FF7B8229BA0, 0x0) = -1 2

stat64("/System/Volumes/Preboot/Cryptexes/OS/usr/lib/system/libsystem_networkextension.dylib\0", 0x7FF7B8229B40, 0x0) = -1 2

stat64("/usr/lib/system/libsystem_networkextension.dylib\0", 0x7FF7B8229BA0, 0x0) = -1 2

stat64("/usr/lib/system/libsystem_asl.dylib\0", 0x7FF7B8229BA0, 0x0) = -1 2

stat64("/System/Volumes/Preboot/Cryptexes/OS/usr/lib/system/libsystem_asl.dylib\0", 0x7FF7B8229B50, 0x0) = -1 2

stat64("/usr/lib/system/libsystem_asl.dylib\0", 0x7FF7B8229BA0, 0x0) = -1 2

stat64("/usr/lib/system/libsystem_symptoms.dylib\0", 0x7FF7B8229BA0, 0x0) = -1 2

stat64("/System/Volumes/Preboot/Cryptexes/OS/usr/lib/system/libsystem_symptoms.dylib\0", 0x7FF7B8229B40, 0x0) = -1 2

stat64("/usr/lib/system/libsystem_symptoms.dylib\0", 0x7FF7B8229BA0, 0x0) = -1 2

stat64("/usr/lib/system/libsystem_containermanager.dylib\0", 0x7FF7B8229BA0, 0x0) = -1 2

stat64("/System/Volumes/Preboot/Cryptexes/OS/usr/lib/system/libsystem_containermanager.dylib\0", 0x7FF7B8229B40, 0x0) = -1 2

stat64("/usr/lib/system/libsystem_containermanager.dylib\0", 0x7FF7B8229BA0, 0x0) = -1 2

stat64("/usr/lib/system/libsystem_configuration.dylib\0", 0x7FF7B8229BA0, 0x0) = -1 2

stat64("/System/Volumes/Preboot/Cryptexes/OS/usr/lib/system/libsystem_configuration.dylib\0", 0x7FF7B8229B40, 0x0) = -1 2

stat64("/usr/lib/system/libsystem_configuration.dylib\0", 0x7FF7B8229BA0, 0x0) = -1 2

stat64("/usr/lib/system/libsystem_sandbox.dylib\0", 0x7FF7B8229BA0, 0x0) = -1 2

stat64("/System/Volumes/Preboot/Cryptexes/OS/usr/lib/system/libsystem_sandbox.dylib\0", 0x7FF7B8229B40, 0x0) = -1 2

stat64("/usr/lib/system/libsystem_sandbox.dylib\0", 0x7FF7B8229BA0, 0x0) = -1 2

stat64("/usr/lib/system/libquarantine.dylib\0", 0x7FF7B8229BA0, 0x0) = -1 2

stat64("/System/Volumes/Preboot/Cryptexes/OS/usr/lib/system/libquarantine.dylib\0", 0x7FF7B8229B50, 0x0) = -1 2

stat64("/usr/lib/system/libquarantine.dylib\0", 0x7FF7B8229BA0, 0x0) = -1 2

stat64("/usr/lib/system/libsystem_coreservices.dylib\0", 0x7FF7B8229BA0, 0x0) = -1 2

stat64("/System/Volumes/Preboot/Cryptexes/OS/usr/lib/system/libsystem_coreservices.dylib\0", 0x7FF7B8229B40, 0x0) = -1 2

stat64("/usr/lib/system/libsystem_coreservices.dylib\0", 0x7FF7B8229BA0, 0x0) = -1 2

stat64("/usr/lib/system/libsystem_m.dylib\0", 0x7FF7B8229BA0, 0x0) = -1 2

stat64("/System/Volumes/Preboot/Cryptexes/OS/usr/lib/system/libsystem_m.dylib\0", 0x7FF7B8229B50, 0x0) = -1 2

stat64("/usr/lib/system/libsystem_m.dylib\0", 0x7FF7B8229BA0, 0x0) = -1 2

stat64("/usr/lib/system/libmacho.dylib\0", 0x7FF7B8229BA0, 0x0) = -1 2

stat64("/System/Volumes/Preboot/Cryptexes/OS/usr/lib/system/libmacho.dylib\0", 0x7FF7B8229B50, 0x0) = -1 2

stat64("/usr/lib/system/libmacho.dylib\0", 0x7FF7B8229BA0, 0x0) = -1 2

stat64("/usr/lib/system/libcommonCrypto.dylib\0", 0x7FF7B8229BA0, 0x0) = -1 2

stat64("/System/Volumes/Preboot/Cryptexes/OS/usr/lib/system/libcommonCrypto.dylib\0", 0x7FF7B8229B40, 0x0) = -1 2

stat64("/usr/lib/system/libcommonCrypto.dylib\0", 0x7FF7B8229BA0, 0x0) = -1 2

stat64("/usr/lib/system/libunwind.dylib\0", 0x7FF7B8229BA0, 0x0) = -1 2

stat64("/System/Volumes/Preboot/Cryptexes/OS/usr/lib/system/libunwind.dylib\0", 0x7FF7B8229B50, 0x0) = -1 2

stat64("/usr/lib/system/libunwind.dylib\0", 0x7FF7B8229BA0, 0x0) = -1 2

stat64("/usr/lib/liboah.dylib\0", 0x7FF7B8229BA0, 0x0) = -1 2

stat64("/System/Volumes/Preboot/Cryptexes/OS/usr/lib/liboah.dylib\0", 0x7FF7B8229B50, 0x0) = -1 2

stat64("/usr/lib/liboah.dylib\0", 0x7FF7B8229BA0, 0x0) = -1 2

stat64("/usr/lib/system/libcopyfile.dylib\0", 0x7FF7B8229BA0, 0x0) = -1 2

stat64("/System/Volumes/Preboot/Cryptexes/OS/usr/lib/system/libcopyfile.dylib\0", 0x7FF7B8229B50, 0x0) = -1 2

stat64("/usr/lib/system/libcopyfile.dylib\0", 0x7FF7B8229BA0, 0x0) = -1 2

stat64("/usr/lib/system/libcompiler_rt.dylib\0", 0x7FF7B8229BA0, 0x0) = -1 2

stat64("/System/Volumes/Preboot/Cryptexes/OS/usr/lib/system/libcompiler_rt.dylib\0", 0x7FF7B8229B50, 0x0) = -1 2

stat64("/usr/lib/system/libcompiler_rt.dylib\0", 0x7FF7B8229BA0, 0x0) = -1 2

stat64("/usr/lib/system/libsystem_collections.dylib\0", 0x7FF7B8229BA0, 0x0) = -1 2

stat64("/System/Volumes/Preboot/Cryptexes/OS/usr/lib/system/libsystem_collections.dylib\0", 0x7FF7B8229B40, 0x0) = -1 2

stat64("/usr/lib/system/libsystem_collections.dylib\0", 0x7FF7B8229BA0, 0x0) = -1 2

stat64("/usr/lib/system/libsystem_secinit.dylib\0", 0x7FF7B8229BA0, 0x0) = -1 2

stat64("/System/Volumes/Preboot/Cryptexes/OS/usr/lib/system/libsystem_secinit.dylib\0", 0x7FF7B8229B40, 0x0) = -1 2

stat64("/usr/lib/system/libsystem_secinit.dylib\0", 0x7FF7B8229BA0, 0x0) = -1 2

stat64("/usr/lib/system/libremovefile.dylib\0", 0x7FF7B8229BA0, 0x0) = -1 2

stat64("/System/Volumes/Preboot/Cryptexes/OS/usr/lib/system/libremovefile.dylib\0", 0x7FF7B8229B50, 0x0) = -1 2

stat64("/usr/lib/system/libremovefile.dylib\0", 0x7FF7B8229BA0, 0x0) = -1 2

stat64("/usr/lib/system/libkeymgr.dylib\0", 0x7FF7B8229BA0, 0x0) = -1 2

stat64("/System/Volumes/Preboot/Cryptexes/OS/usr/lib/system/libkeymgr.dylib\0", 0x7FF7B8229B50, 0x0) = -1 2

stat64("/usr/lib/system/libkeymgr.dylib\0", 0x7FF7B8229BA0, 0x0) = -1 2

stat64("/usr/lib/system/libsystem_dnssd.dylib\0", 0x7FF7B8229BA0, 0x0) = -1 2

stat64("/System/Volumes/Preboot/Cryptexes/OS/usr/lib/system/libsystem_dnssd.dylib\0", 0x7FF7B8229B40, 0x0) = -1 2

stat64("/usr/lib/system/libsystem_dnssd.dylib\0", 0x7FF7B8229BA0, 0x0) = -1 2

stat64("/usr/lib/system/libcache.dylib\0", 0x7FF7B8229BA0, 0x0) = -1 2

stat64("/System/Volumes/Preboot/Cryptexes/OS/usr/lib/system/libcache.dylib\0", 0x7FF7B8229B50, 0x0) = -1 2

stat64("/usr/lib/system/libcache.dylib\0", 0x7FF7B8229BA0, 0x0) = -1 2

stat64("/usr/lib/libSystem.B.dylib\0", 0x7FF7B8229BA0, 0x0) = -1 2

stat64("/System/Volumes/Preboot/Cryptexes/OS/usr/lib/libSystem.B.dylib\0", 0x7FF7B8229B50, 0x0) = -1 2

stat64("/usr/lib/libSystem.B.dylib\0", 0x7FF7B8229BA0, 0x0) = -1 2

stat64("/usr/lib/system/libsystem_darwindirectory.dylib\0", 0x7FF7B8229BA0, 0x0) = -1 2

stat64("/System/Volumes/Preboot/Cryptexes/OS/usr/lib/system/libsystem_darwindirectory.dylib\0", 0x7FF7B8229B40, 0x0) = -1 2

stat64("/usr/lib/system/libsystem_darwindirectory.dylib\0", 0x7FF7B8229BA0, 0x0) = -1 2

stat64("/usr/lib/libconv.2.dylib\0", 0x7FF7B822BE70, 0x0) = -1 2

stat64("/System/Volumes/Preboot/Cryptexes/OS/usr/lib/libconv.2.dylib\0", 0x7FF7B822BE20, 0x0) = -1 2

stat64("/usr/lib/libconv.2.dylib\0", 0x7FF7B822BE70, 0x0) = -1 2

stat64("/usr/lib/libcharset.1.dylib\0", 0x7FF7B8229AC0, 0x0) = -1 2

stat64("/System/Volumes/Preboot/Cryptexes/OS/usr/lib/libcharset.1.dylib\0", 0x7FF7B8229A70, 0x0) = -1 2

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stat64("/usr/lib/libcharset.1.dylib\0", 0x7FF7B8229AC0, 0x0)      = -1 2

stat64("/usr/lib/libiconv.2.dylib\0", 0x7FF7B8229AC0, 0x0)      = -1 2

stat64("/System/Volumes/Preboot/Cryptexes/OS/usr/lib/libiconv.2.dylib\0", 0x7FF7B8229A70, 0x0)  = -1 2

stat64("/usr/lib/libiconv.2.dylib\0", 0x7FF7B8229AC0, 0x0)      = -1 2

open("@rpath/libgcc_s.1.1.dylib\0", 0x0, 0x0)                  = -1 2

open("@rpath\0", 0x100000, 0x0)                                  = -1 2

stat64("/usr/lib/libSystem.B.dylib\0", 0x7FF7B822BE70, 0x0)     = -1 2

stat64("/System/Volumes/Preboot/Cryptexes/OS/usr/lib/libSystem.B.dylib\0", 0x7FF7B822BE20, 0x0)  = -1 2

stat64("/usr/lib/libSystem.B.dylib\0", 0x7FF7B822BE70, 0x0)     = -1 2

open("/dev/dtracehelper\0", 0x2, 0x0)                           = 3 0

ioctl(0x3, 0x80086804, 0x7FF7B822B9D8)                         = 0 0

close(0x3)                                                       = 0 0

open("/Users/mishazhadnov/Desktop/wD/OS_labs_3t/lab2/scr/prog\0", 0x0, 0x0)      = 3 0

__mac_syscall(0x7FF808646E3B, 0x2, 0x7FF7B822B0B0)             = 0 0

map_with_linking_np(0x7FF7B822ABA0, 0x1, 0x7FF7B822ABD0)        = -1 22

close(0x3)                                                       = 0 0

mprotect(0x107CDA000, 0x4000, 0x1)                               = 0 0

open("/usr/local/Cellar/gcc/13.2.0/lib/gcc/current/libstdc++.6.dylib\0", 0x0, 0x0)  = 3 0

__mac_syscall(0x7FF808646E3B, 0x2, 0x7FF7B822B0B0)             = 0 0

map_with_linking_np(0x7FF7B8228210, 0x2, 0x7FF7B8228260)        = -1 22

close(0x3)                                                       = 0 0

mprotect(0x1087E8000, 0xC000, 0x1)                               = 0 0

shared_region_check_np(0xFFFFFFFFFFFFFFFF, 0x0, 0x0)           = 0 0

mprotect(0x108200000, 0x40000, 0x1)                             = 0 0

access("/AppleInternal/XBS/.isChrooted\0", 0x0, 0x0)           = -1 2

bsdthread_register(0x7FF808939B9C, 0x7FF808939B88, 0x2000)      = 1073742303 0

getpid(0x0, 0x0, 0x0)                                           = 1981 0

shm_open(0x7FF8087DCF42, 0x0, 0x87DB388)                       = 3 0

fstat64(0x3, 0x7FF7B822C020, 0x0)                               = 0 0

mmap(0x0, 0x4000, 0x1, 0x40001, 0x3, 0x0)                      = 0x107CEC000 0

close(0x3)                                                       = 0 0

ioctl(0x2, 0x4004667A, 0x7FF7B822C0E4)                         = 0 0

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mprotect(0x107CF5000, 0x1000, 0x0)      = 0 0

mprotect(0x107CFC000, 0x1000, 0x0)      = 0 0

mprotect(0x108101000, 0x1000, 0x0)      = 0 0

mprotect(0x108108000, 0x1000, 0x0)      = 0 0

mprotect(0x107CF0000, 0x98, 0x1)        = 0 0

mprotect(0x107CF0000, 0x98, 0x3)        = 0 0

mprotect(0x107CF0000, 0x98, 0x1)        = 0 0

mprotect(0x107CFD000, 0x1000, 0x1)      = 0 0

mprotect(0x108109000, 0x98, 0x1)        = 0 0

mprotect(0x108109000, 0x98, 0x3)        = 0 0

mprotect(0x108109000, 0x98, 0x1)        = 0 0

mprotect(0x107CF0000, 0x98, 0x3)        = 0 0

mprotect(0x107CF0000, 0x98, 0x1)        = 0 0

mprotect(0x107CFD000, 0x1000, 0x3)      = 0 0

mprotect(0x107CFD000, 0x1000, 0x1)      = 0 0

mprotect(0x108200000, 0x40000, 0x3)      = 0 0

mprotect(0x108200000, 0x40000, 0x1)      = 0 0

issetugid(0x0, 0x0, 0x0)              = 0 0

mprotect(0x108200000, 0x40000, 0x3)      = 0 0

mprotect(0x108200000, 0x40000, 0x1)      = 0 0

mprotect(0x108200000, 0x40000, 0x3)      = 0 0

mprotect(0x108200000, 0x40000, 0x1)      = 0 0

getattrlist("/Users/mishazhadnov/Desktop/wD/OS_labs_3t/lab2/scr/prog\0", 0x7FF7B822BFC0, 0x7FF7B822BFD8) = 0 0

access("/Users/mishazhadnov/Desktop/wD/OS_labs_3t/lab2/scr\0", 0x4, 0x0)          = 0 0

open("/Users/mishazhadnov/Desktop/wD/OS_labs_3t/lab2/scr\0", 0x0, 0x0)            = 3 0

fstat64(0x3, 0x7FB6E8F04530, 0x0)          = 0 0

csctl(0x0, 0x7FF7B822C21C, 0x4)            = -1 1

fgetattrlist(0x3, 0x7FF7B822C230, 0x7FF7B822C250) = 0 0

__mac_syscall(0x7FF813CFA6A4, 0x2, 0x7FF7B822C250) = 0 0

fcntl(0x3, 0x32, 0x7FF7B822BED0)           = 0 0

close(0x3)                                  = 0 0

open("/Users/mishazhadnov/Desktop/wD/OS_labs_3t/lab2/scr/Info.plist\0", 0x0, 0x0) = -1 2

```

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proc_info(0x2, 0x7BD, 0xD)          = 64 0

csops_audittoken(0x7BD, 0x10, 0x7FF7B822C220)    = -1 22

dtrace: error on enabled probe ID 1741 (ID 573: syscall::syscall:return): invalid kernel access in action #10 at DIF offset 28

dtrace: error on enabled probe ID 1741 (ID 573: syscall::syscall:return): invalid kernel access in action #10 at DIF offset 28

csops(0x7BD, 0x0, 0x7FF7B822C684)          = 0 0

sysctlbyname(kern.system_version_compat, 0x1A, 0x0, 0x0, 0x7FF7B822C6B4)          = 0 0

mprotect(0x10820000, 0x40000, 0x3)          = 0 0

getrlimit(0x1008, 0x7FF7B822D420, 0x0)          = 0 0

fstat64(0x1, 0x7FF7B822D408, 0x0)          = 0 0

ioctl(0x1, 0x4004667A, 0x7FF7B822D454)          = 0 0

fstat64(0x0, 0x7FF7B822D048, 0x0)          = 0 0

dtrace: error on enabled probe ID 1714 (ID 961: syscall::read_nocancel:return): invalid kernel access in action #12 at DIF offset 68

dtrace: error on enabled probe ID 1714 (ID 961: syscall::read_nocancel:return): invalid kernel access in action #12 at DIF offset 68

bsdthread_create(0x107CD5694, 0x600001625200, 0x70000485B000)          = 75870208 0

thread_selfid(0x0, 0x0, 0x0)          = 526321 0

bsdthread_create(0x107CD5694, 0x600001625208, 0x7000048DE000)          = 76406784 0

__disable_threadsignal(0x1, 0x0, 0x0)          = 0 0

bsdthread_create(0x107CD5694, 0x600001625210, 0x700004961000)          = 76943360 0

thread_selfid(0x0, 0x0, 0x0)          = 526322 0

thread_selfid(0x0, 0x0, 0x0)          = 526323 0

__disable_threadsignal(0x1, 0x0, 0x0)          = 0 0

__disable_threadsignal(0x1, 0x0, 0x0)          = 0 0

ulock_wake(0x1000002, 0x7000048DE034, 0x0)          = 0 0

ulock_wait(0x1020002, 0x7000048DE034, 0x1B0B)          = 0 0

dtrace: error on enabled probe ID 1712 (ID 963: syscall::write_nocancel:return): invalid kernel access in action #12 at DIF offset 68

dtrace: error on enabled probe ID 1712 (ID 963: syscall::write_nocancel:return): invalid kernel access in action #12 at DIF offset 68

dtrace: error on enabled probe ID 1712 (ID 963: syscall::write_nocancel:return): invalid kernel access in action #12 at DIF offset 68

dtrace: error on enabled probe ID 1712 (ID 963: syscall::write_nocancel:return): invalid kernel access in action #12 at DIF offset 68

```

Вывод

Я осуществил многопоточность в своей программе, выполняя лабораторную работу.

Я понял, что не каждому алгоритму подходит многопоточность, это зависит от того, насколько линейный алгоритм, то есть, как часто используется один и тот же фрагмент памяти, и на скорость это также влияет. Почему это важное замечание? Потоки используют общую память, им не выделяется, как процессам, своя, в результате чего несколько потоков могут пытаться изменить один и тот же участок памяти, но здесь это решалось завершением потока.

Также не стоит надеяться, что многопоточность – панацея для ускорения программ.

Это в какой-то мере абстракция, так как настоящая параллельная работа может осуществляться только на разных ядрах. В другом случае процессор работает в режиме псевдопараллельности. У меня максимальная скорость была на 4 потоках, а максимальная эффективность (один не в счет) на 2, потому что реальных 2 ядра, еще 2 виртуальных, то есть всего 4 потока.

Создание потоков также занимает время. Отсюда следует, что никому не нужно огромное количество потоков. Это сильно нагружает процессор, который еще может обслуживать другие процессы. Если представить, что большинство программ использует несколько потоков, кажется, что выигрыша в скорости мы не получим.

И все-таки на небольшом количестве потоков было заметное ускорение, так что потоки – полезная и важная вещь, которую нужно знать.