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05/14/2018

CSC 656

Project # 3

Part a:

```
// File: MaxCol.cu
// Compile: nvcc MaxCol.cu -o mc
// Run: ./mc [width of matrix] [threads per block]

// Description: finds the max of each column of a randomly generated matrix
//         in kernel findMax(), each thread finds the max of one column

#include <stdio.h>
#include <stdlib.h>
#include <cuda.h>

#define THREADSPERBLOCK 4

int checkArray(int [], int [], int);

__global__ void findMax(int *m, int *rs, int n);

int main(int argc, char **argv)
{
    /* variables for timing */
    cudaEvent_t start, stop;
    float time;

    if (argc != 3) {
        printf("Usage: ./SR [width of matrix] [threads per block]\n");
        exit(0);
    }

    int n = atoi(argv[1]);  // number of matrix rows/cols
    int *hm, // host matrix
    *dm, // device matrix
    *hcs, // host column sums
    *dcs; // device column sums
    int *checkCs;
    int msize = n * n * sizeof(int);  // size of matrix in bytes
    int rssize = n * sizeof(int);
    int threadsPerBlock = atoi(argv[2]); // get threads per block

    if (n % threadsPerBlock != 0) {
        printf("Warning: width of matrix not divisible by # threads per block\n");
    }

    // allocate space for host matrix
    hm = (int *) malloc(msize);
```

```
// create timer events
cudaEventCreate(&start);
cudaEventCreate(&stop);

// as a test, fill matrix with random integers

int i, j;
for (i = 0; i < n; i++) {
    for (j = 0; j < n; j++) {
        hm[i*n+j] = random() % RAND_MAX;
    }
}

// compute max of columns on CPU for checking
checkCs = (int *) malloc(rssize);
for (i=0; i<n; i++) {
    checkCs[i] = hm[i];
    for (j=0; j<n; j++) {
        if (checkCs[i] < hm[i + j*n])
            checkCs[i] = hm[i + j*n];
    }
}

// allocate space for device matrix
cudaMalloc((void **)&dm,msize);
// copy host matrix to device matrix
cudaMemcpy(dm,hm,msize,cudaMemcpyHostToDevice);
// allocate host, device rowsum arrays
hcs = (int *) malloc(rssize);
cudaMalloc((void **)&dcs,rssize);

// record start timestamp
cudaEventRecord(start, 0);

// invoke the kernel
findMax<<<n/threadsPerBlock,threadsPerBlock>>>(dm,dcs,n);
// wait for kernel to finish
cudaThreadSynchronize();
// copy row vector from device to host
cudaMemcpy(hcs,dcs,rssize,cudaMemcpyDeviceToHost);

// get elapsed time
cudaEventRecord(stop, 0);
cudaEventSynchronize(stop);
cudaEventElapsedTime(&time, start, stop);
```

```
    printf("Elapsed time = %f\n", time);

    // check results
    int diff = checkArray(hcs, checkCs, n);
    if (diff == 0) {
        printf("Arrays match\n");
    }
    else {
        printf("Arrays do not match\n");
    }


    // clean up
    free(hm);
    cudaFree(dm);
    free(hcs);
    cudaFree(dcs);
}

int checkArray(int x[], int y[], int size) {
    int i;
    int numDiff = 0;
    for (i=0; i<size; i++) {
        if (x[i] != y[i]) {
            numDiff++;
        }
    }
    return numDiff;
}

// findMax(int *m, int *cs, int n)
// m: n x n matrix (input)
// cs: cs[i] contains max of columnn i of m (output)
// n: number of elements in each row/column of m

__global__ void findMax(int *m, int *cs, int n)
{
    // your code goes here
    int column = blockDim.x *blockIdx.x + threadIdx.x;
    int maxnum =0;
    for (int i=0; i < n ;i++){

        if (maxnum <=m[i*n +column])
            maxnum = m[i*n +column];
    }
    cs[column]=maxnum;

}
```

Result table for Part a:

	8 threads	16 threads	32 threads	64 threads	128 threads
Size 1024	0.217376	0.2239168	0.2313152	0.212544	0.2137088
Size 2048	0.6244928	0.364992	0.3675968	0.3648512	0.3684608
Size 4096	1.672224	1.138528	0.644608	0.6486592	0.6529728

Part b:

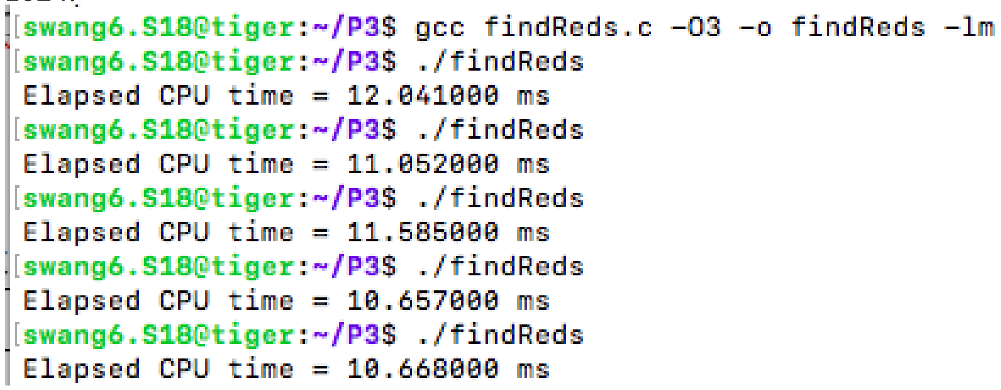
```
/****
File: findRedsDriver.cu
Date: 5/14/2018
By: Shenliang Wang
Compile: nvcc findRedsDriver.cu -o findreadsdriver
Run: ./findreadsdriver

****/

#include <stdio.h>
#include <math.h>
#include <stdlib.h>
#include <cuda.h>

#define NUMPARTICLES 32768
#define NEIGHBORHOOD .05
#define THREADSPERBLOCK 128

void initPos(float *);
float findDistance(float *, int, int);
__device__ float findDistanceGPU(float *, int, int);
void dumpResults(int index[]);

__global__ void findRedsGPU(float *p, int *numI);

int main() {
    cudaEvent_t start, stop;
    float time;

    float *pos, *dpos;
    int *numReds, *dnumReds;
    pos = (float *) malloc(NUMPARTICLES * 4 * sizeof(float));
    numReds = (int *) malloc(NUMPARTICLES * sizeof(int));

    initPos(pos);

// your code to allocate device arrays for pos and numReds go here

    cudaMalloc((void **)&dpos,NUMPARTICLES * 4 * sizeof(float));

    cudaMalloc((void **)&dnumReds,NUMPARTICLES * sizeof(int));

    cudaMemcpy(dpos,pos,NUMPARTICLES * 4 * sizeof(float),cudaMemcpyHostToDevice);


// create timer events
    cudaEventCreate(&start);
    cudaEventCreate(&stop);

    cudaEventRecord(start, 0);

/* invoke kernel findRedsGPU here */


findRedsGPU<<<NUMPARTICLES/THREADSPERBLOCK,THREADSPERBLOCK>>>(dpos,dnumRed
s);

    cudaThreadSynchronize();

// your code to copy results to numReds[] go here

    cudaMemcpy(numReds,dnumReds,NUMPARTICLES * sizeof(int),cudaMemcpyDeviceToHost);

    cudaEventRecord(stop, 0);
    cudaEventSynchronize(stop);
    cudaEventElapsedTime(&time, start, stop);

    printf("Elapsed time = %f\n", time);

    dumpResults(numReds);

}

void initPos(float *p) {

// your code for initializing pos goes here
```

```
    int i;
    int j;
    for (i=0; i<NUMPARTICLES; i++) {
    p[i*4] = rand() / (float) RAND_MAX;
    p[i*4+1] = rand() / (float) RAND_MAX;
    p[i*4+2] = rand() / (float) RAND_MAX;
    j = rand() % 3;
    if (j == 0)
        p[i*4+3] = 0xff0000;
    else if (j == 1)
        p[i*4+3] = 0x00ff00;
    else
    p[i*4+3] = 0x0000ff;
}


}

__device__ float findDistanceGPU(float *p, int i, int j) {

// your code for calculating distance for particle i and j

    float x, y, z;

    x = p[i*4] - p[j*4];
    y = p[i*4+1] - p[j*4+1];
    z = p[i*4+2] - p[j*4+2];

    return(sqrt(x*x + y*y + z*z));

}

__global__ void findRedsGPU(float *p, int *numI) {

    int index = blockDim.x * blockIdx.x + threadIdx.x;
    int i;
    float d;

    numI[index] = 0;
    for (i=0; i<NUMPARTICLES; i++) {
        if (index!=i) {
            d = findDistanceGPU(p, index, i);
            if (d < NEIGHBORHOOD && p[i*4+3] == 0xff0000) {
                numI[index]++;
            }
        }
    }

}
void dumpResults(int index[]) {
    int i;
    FILE *fp;

    fp = fopen("./dump.out", "w");

    for (i=0; i<NUMPARTICLES; i++) {
        fprintf(fp, "%d %d\n", i, index[i]);
    }
    fclose(fp);
}
```

Result table for b:
CPU:

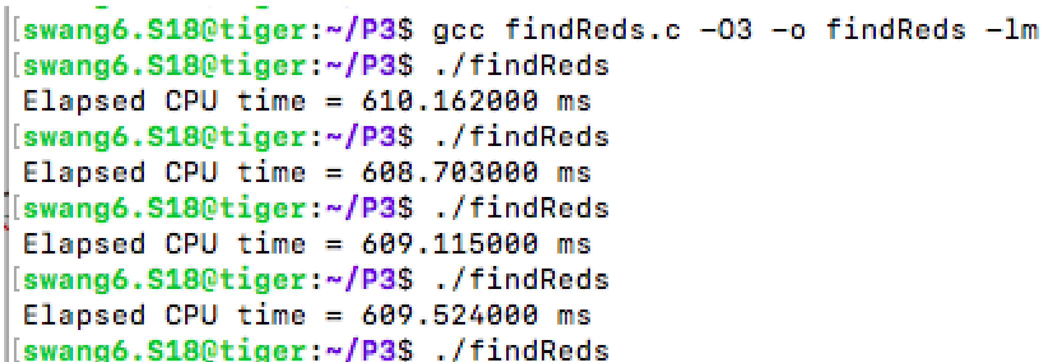
	NUMPARTICLES = 1024	NUMPARTICLES = 8192	NUMPARTICLES = 32768
time	9711.069800ms	609.143600ms	11.200600ms

Data
1024:



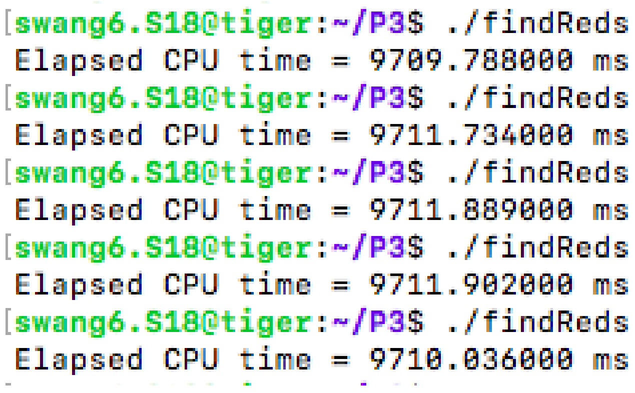
```
[swang6.S18@tiger:~/P3$ gcc findReds.c -O3 -o findReds -lm
[swang6.S18@tiger:~/P3$ ./findReds
 Elapsed CPU time = 12.041000 ms
[swang6.S18@tiger:~/P3$ ./findReds
 Elapsed CPU time = 11.052000 ms
[swang6.S18@tiger:~/P3$ ./findReds
 Elapsed CPU time = 11.585000 ms
[swang6.S18@tiger:~/P3$ ./findReds
 Elapsed CPU time = 10.657000 ms
[swang6.S18@tiger:~/P3$ ./findReds
 Elapsed CPU time = 10.668000 ms
```

8192



```
[swang6.S18@tiger:~/P3$ gcc findReds.c -O3 -o findReds -lm
[swang6.S18@tiger:~/P3$ ./findReds
 Elapsed CPU time = 610.162000 ms
[swang6.S18@tiger:~/P3$ ./findReds
 Elapsed CPU time = 608.703000 ms
[swang6.S18@tiger:~/P3$ ./findReds
 Elapsed CPU time = 609.115000 ms
[swang6.S18@tiger:~/P3$ ./findReds
 Elapsed CPU time = 609.524000 ms
[swang6.S18@tiger:~/P3$ ./findReds
```

32768:

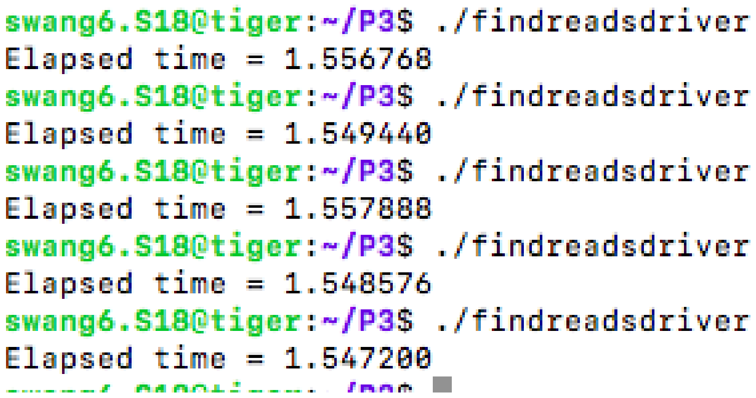


```
[swang6.S18@tiger:~/P3$ ./findReds
 Elapsed CPU time = 9709.788000 ms
[swang6.S18@tiger:~/P3$ ./findReds
 Elapsed CPU time = 9711.734000 ms
[swang6.S18@tiger:~/P3$ ./findReds
 Elapsed CPU time = 9711.889000 ms
[swang6.S18@tiger:~/P3$ ./findReds
 Elapsed CPU time = 9711.902000 ms
[swang6.S18@tiger:~/P3$ ./findReds
 Elapsed CPU time = 9710.036000 ms
```

GPU:

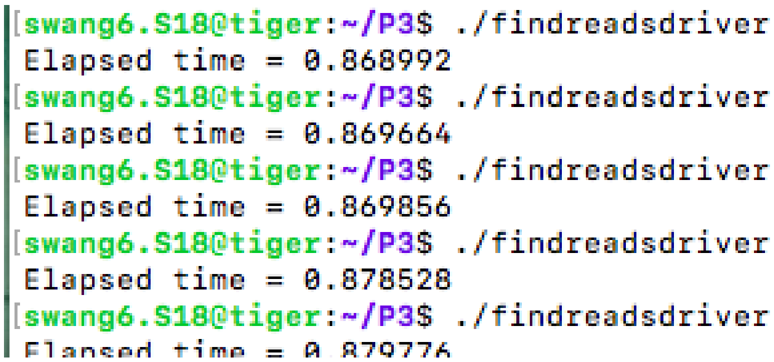
	4 threads	16 threads	64 threads
NUMPARTICLES = 1024	1.5519744	0.8733632	0.8882816
NUMPARTICLES = 8192	54.241005	19.8361792	8.979104
NUMPARTICLES = 32768	711.3262816	209.1328644	133.829152

NUMPARTICLES = 1024. 4 threads



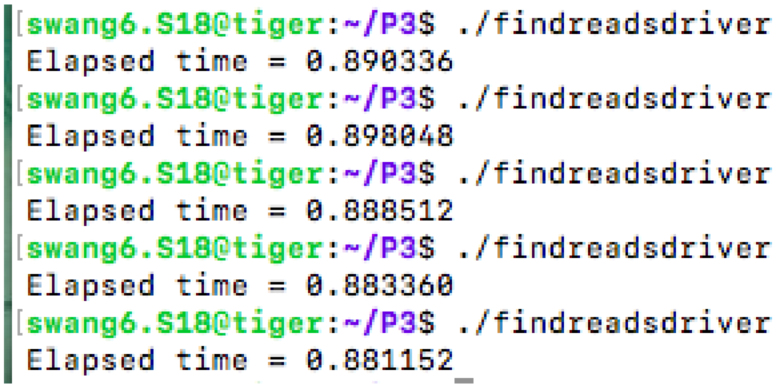
```
swang6.S18@tiger:~/P3$ ./findreadsdriver
Elapsed time = 1.556768
swang6.S18@tiger:~/P3$ ./findreadsdriver
Elapsed time = 1.549440
swang6.S18@tiger:~/P3$ ./findreadsdriver
Elapsed time = 1.557888
swang6.S18@tiger:~/P3$ ./findreadsdriver
Elapsed time = 1.548576
swang6.S18@tiger:~/P3$ ./findreadsdriver
Elapsed time = 1.547200
```

NUMPARTICLES = 1024. 16 threads



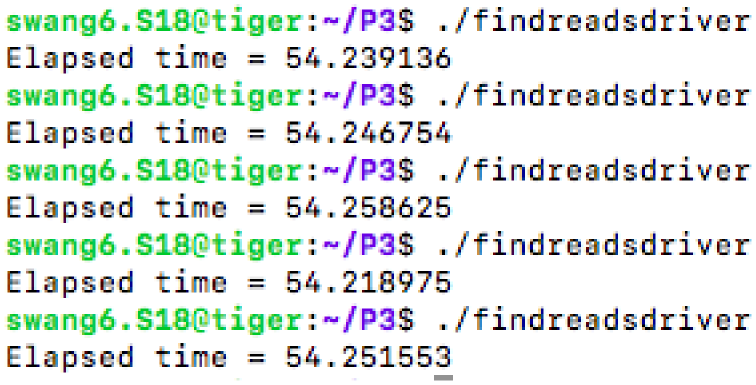
```
[swang6.S18@tiger:~/P3$ ./findreadsdriver
Elapsed time = 0.868992
[swang6.S18@tiger:~/P3$ ./findreadsdriver
Elapsed time = 0.869664
[swang6.S18@tiger:~/P3$ ./findreadsdriver
Elapsed time = 0.869856
[swang6.S18@tiger:~/P3$ ./findreadsdriver
Elapsed time = 0.878528
[swang6.S18@tiger:~/P3$ ./findreadsdriver
Elapsed time = 0.879776
```

NUMPARTICLES = 1024. 64 threads



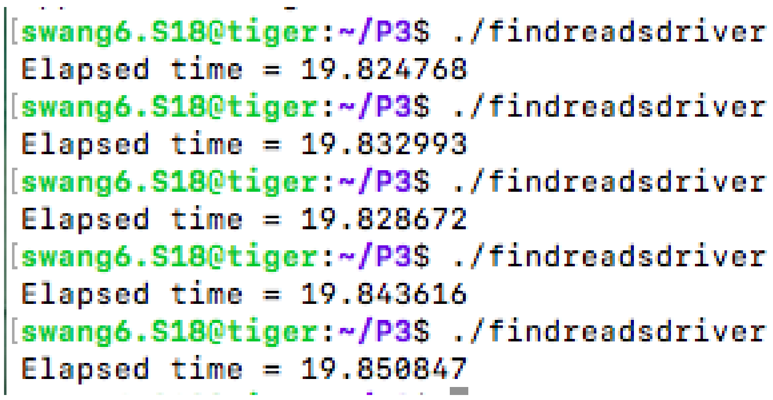
```
[swang6.S18@tiger:~/P3$ ./findreadsdriver
Elapsed time = 0.890336
[swang6.S18@tiger:~/P3$ ./findreadsdriver
Elapsed time = 0.898048
[swang6.S18@tiger:~/P3$ ./findreadsdriver
Elapsed time = 0.888512
[swang6.S18@tiger:~/P3$ ./findreadsdriver
Elapsed time = 0.883360
[swang6.S18@tiger:~/P3$ ./findreadsdriver
Elapsed time = 0.881152
```

NUMPARTICLES = 8192. 4 threads



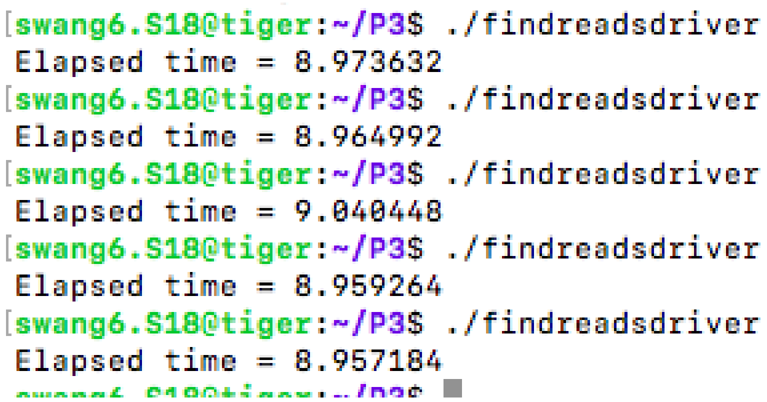
```
swang6.S18@tiger:~/P3$ ./findreadsdriver
Elapsed time = 54.239136
swang6.S18@tiger:~/P3$ ./findreadsdriver
Elapsed time = 54.246754
swang6.S18@tiger:~/P3$ ./findreadsdriver
Elapsed time = 54.258625
swang6.S18@tiger:~/P3$ ./findreadsdriver
Elapsed time = 54.218975
swang6.S18@tiger:~/P3$ ./findreadsdriver
Elapsed time = 54.251553
```

NUMPARTICLES = 8192. 16 threads



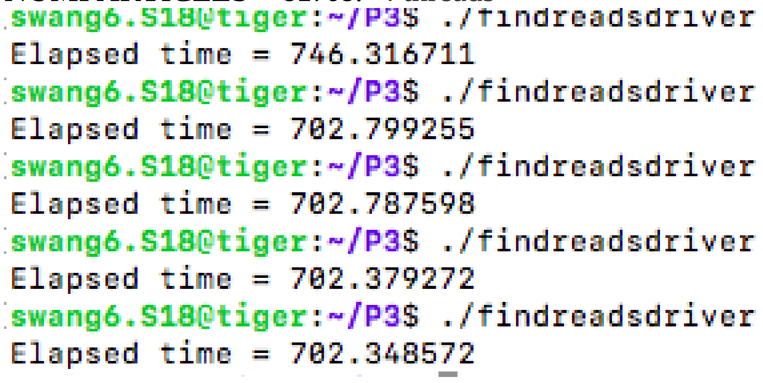
```
swang6.S18@tiger:~/P3$ ./findreadsdriver
Elapsed time = 19.824768
swang6.S18@tiger:~/P3$ ./findreadsdriver
Elapsed time = 19.832993
swang6.S18@tiger:~/P3$ ./findreadsdriver
Elapsed time = 19.828672
swang6.S18@tiger:~/P3$ ./findreadsdriver
Elapsed time = 19.843616
swang6.S18@tiger:~/P3$ ./findreadsdriver
Elapsed time = 19.850847
```

NUMPARTICLES = 8192. 64 threads



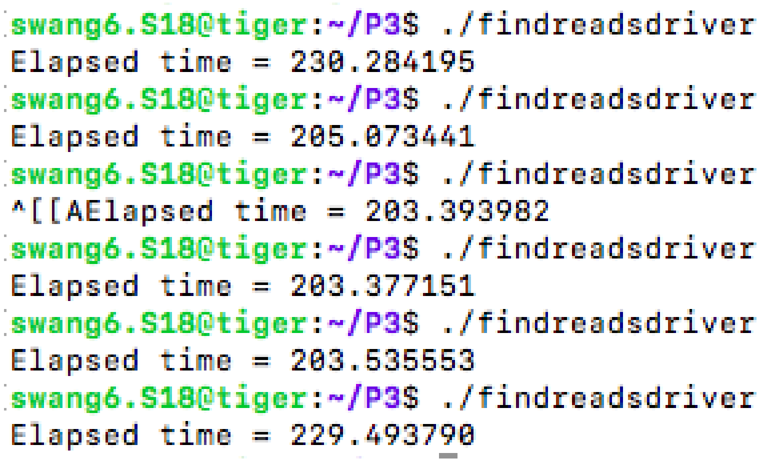
```
swang6.S18@tiger:~/P3$ ./findreadsdriver
Elapsed time = 8.973632
swang6.S18@tiger:~/P3$ ./findreadsdriver
Elapsed time = 8.964992
swang6.S18@tiger:~/P3$ ./findreadsdriver
Elapsed time = 9.040448
swang6.S18@tiger:~/P3$ ./findreadsdriver
Elapsed time = 8.959264
swang6.S18@tiger:~/P3$ ./findreadsdriver
Elapsed time = 8.957184
```

NUMPARTICLES = 32768. 4 threads



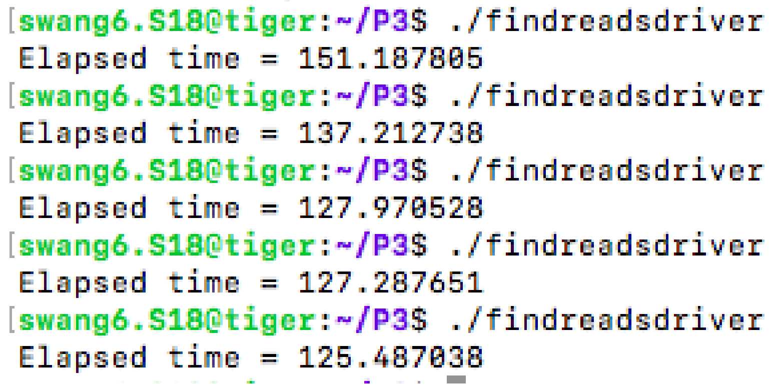
```
swang6.S18@tiger:~/P3$ ./findreadsdriver
Elapsed time = 746.316711
swang6.S18@tiger:~/P3$ ./findreadsdriver
Elapsed time = 702.799255
swang6.S18@tiger:~/P3$ ./findreadsdriver
Elapsed time = 702.787598
swang6.S18@tiger:~/P3$ ./findreadsdriver
Elapsed time = 702.379272
swang6.S18@tiger:~/P3$ ./findreadsdriver
Elapsed time = 702.348572
```

NUMPARTICLES = 32768. 16threads



```
swang6.S18@tiger:~/P3$ ./findreadsdriver
Elapsed time = 230.284195
swang6.S18@tiger:~/P3$ ./findreadsdriver
Elapsed time = 205.073441
swang6.S18@tiger:~/P3$ ./findreadsdriver
^[[AElapsed time = 203.393982
swang6.S18@tiger:~/P3$ ./findreadsdriver
Elapsed time = 203.377151
swang6.S18@tiger:~/P3$ ./findreadsdriver
Elapsed time = 203.535553
swang6.S18@tiger:~/P3$ ./findreadsdriver
Elapsed time = 229.493790
```

NUMPARTICLES = 32768. 64 threads



```
[swang6.S18@tiger:~/P3$ ./findreadsdriver
 Elapsed time = 151.187805
[swang6.S18@tiger:~/P3$ ./findreadsdriver
 Elapsed time = 137.212738
[swang6.S18@tiger:~/P3$ ./findreadsdriver
 Elapsed time = 127.970528
[swang6.S18@tiger:~/P3$ ./findreadsdriver
 Elapsed time = 127.287651
[swang6.S18@tiger:~/P3$ ./findreadsdriver
 Elapsed time = 125.487038
```