ΕΘΝΙΚΟ ΜΕΤΣΟΒΙΟ ΠΟΛΥΤΕΧΝΕΙΟ

ΣΧΟΛΗ ΗΜ&ΜΥ
Συστήματα Παράλληλης Επεξεργασίας 1η Άσκηση
Ακ. έτος 2012-2013

Ομάδα 8η

Μαυρογιάννης Αλέξανδρος Α.Μ.: 03109677
Λύρας Γρηγόρης Α.Μ.: 03109687

11 Νοεμβρίου 2012

Πηγαίος κώδικας

Κοινή βιβλιοθήκη

```c
/* -.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.
* File Name : common.h
* Creation Date : 06-11-2012
* Last Modified : Sun 11 Nov 2012 06:12:55 PM EET
* Created By : Greg Liras <gregliras@gmail.com>
_.-._.-._.-._.-._.-._.-._.-._.-._.-._.-._.-._.-._.-._.-._.-._.-._.*/

#ifndef DEBUG_FUNC
#define DEBUG_FUNC

#if main_DEBUG
#define debug(fmt,arg...)     fprintf(stdout, "%s: " fmt, __func__ , ##arg)
#else
#define debug(fmt,arg...)     do { } while(0)
#endif /* main_DEBUG */

#endif /* DEBUG_FUNC */

#ifndef COMMON_H
#define COMMON_H



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

double *allocate_2d(int N, int M);
double *allocate_2d_with_padding(int N, int M, int max_rank);
double *parse_matrix_2d(FILE *fp, int N, int M, double *A);
void fprint_matrix_2d(FILE *fp, int N, int M, double *A);
void print_matrix_2d(int N, int M, double *A);
double timer(void);
void usage(int argc, char **argv);

#ifdef USE_MPI /* USE_MPI */
void propagate_with_send(void *buffer, int count , MPI_Datatype datatype, int root, MPI_Comm comm);
void propagate_with_flooding(void *buffer, int count , MPI_Datatype datatype, int root, MPI_Comm comm);
#endif /* USE_MPI */

#endif /* COMMON_H */
```

```c
/* -.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.
* File Name : common.c
* Creation Date : 06-11-2012
* Last Modified : Sun 11 Nov 2012 06:40:49 PM EET
* Created By : Greg Liras <gregliras@gmail.com>
_.-._.-._.-._.-._.-._.-._.-._.-._.-._.-._.-._.-._.-._.-._.-._.-._.*/

#include "common.h"
#include <sys/time.h>

double *allocate_2d(int N, int M)
{
    double *A;
    A = malloc(N * M * sizeof(double));
    return A;
}

double *allocate_2d_with_padding(int N, int M, int max_rank)
{
    double *A;
    A = allocate_2d(N + max_rank, M);
    return A;
}


double *parse_matrix_2d(FILE *fp, int N, int M, double *A)
{
    int i,j;
    double *p;
```

```
    p = A;
    for (i = 0; i < N; i++) {
        for (j = 0; j < M; j++) {
            if(!fscanf(fp, "%lf", p++)) {
                return NULL;
            }
        }
    }
    return A;
}

void fprint_matrix_2d(FILE *fp, int N, int M, double *A)
{
    int i,j;
    double *p;
    p = A;
    for (j = 0; j < M; j++) {
        fprintf(fp, "=");
    }
    fprintf(fp, "\n");
    for (i = 0; i < N; i++) {
        for (j = 0; j < M; j++) {
            fprintf(fp, "%lf\t", *p++);
        }
        fprintf(fp, "\n");
    }
    for (j = 0; j < M; j++) {
        fprintf(fp, "=");
    }
    fprintf(fp, "\n");
}

void print_matrix_2d(int N, int M, double *A)
{
    fprint_matrix_2d(stdout, N, M, A);
}


double timer(void)
{
    static double seconds = 0;
    static int operation = 0;
    struct timeval tv;
    gettimeofday(&tv, NULL);
    if (operation == 0) {
        seconds = tv.tv_sec + (((double) tv.tv_usec)/1e6);
        operation = 1;
        return 0;
    }
    else {
        operation = 0;
        return tv.tv_sec + (((double) tv.tv_usec)/1e6) - seconds;
    }
}

void usage(int argc, char **argv)
{
    if(argc != 3) {
        printf("Usage: %s <matrix file> <output file>\n", argv[0]);
        exit(EXIT_FAILURE);
    }
}

#ifdef USE_MPI /* USE_MPI */
void propagate_with_send(void *buffer, int count, MPI_Datatype datatype, int root, MPI_Comm comm)
{
    int rank;
    int i;
    int max_rank;

    MPI_Comm_rank(comm, &rank);
    MPI_Comm_size(comm, &max_rank);
    if(rank == root) {
        for(i = 0; i < max_rank; i++) {
            if(i == rank) {
```

```
                continue;
            }
            else {
                debug("%d\n", i);
                MPI_Send(buffer, count, datatype, i, root, comm);
            }
        }
    }
    else {
        MPI_Status status;
        MPI_Recv(buffer, count, datatype, root, root, comm, &status);
    }



}

void propagate_with_flooding(void *buffer, int count , MPI_Datatype datatype, int root, MPI_Comm comm)
{
    int rank;
    int max_rank;
    int cur;

    MPI_Comm_rank(comm, &rank);
    MPI_Comm_size(comm, &max_rank);

    if(root != 0) {
        if(rank == root) {
            MPI_Send(buffer, count, datatype, 0, root, comm);
        }
        if(rank == 0) {
            MPI_Status status;
            MPI_Recv(buffer, count, datatype, root, root, comm, &status);
        }
    }


    if(rank != 0) {
        MPI_Status status;
        MPI_Recv(buffer, count, datatype, (rank-1)/2, root, comm, &status);
    }
    cur = 2*rank+1;
    if(cur < max_rank) {
        MPI_Send(buffer, count, datatype, cur, root, comm);
    }
    if(++cur < max_rank) {
        MPI_Send(buffer, count, datatype, cur, root, comm);
    }
}
#endif /* USE_MPI */
```

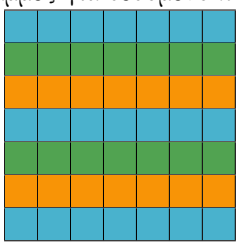
Ζητούμενο 1 Σειριακό Πρόγραμμα

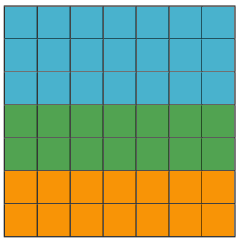
```
/* -.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.
* File Name : main.c
* Creation Date : 30-10-2012
* Last Modified : Thu 08 Nov 2012 09:50:55 AM EET
* Created By : Greg Liras <gregliras@gmail.com>
* Created By : Alex Maurogiannis <nalfemp@gmail.com>
_.-._.-._.-._.-._.-._.-._.-._.-._.-._.-._.-._.-._.-._.-._.-._.-._.-._.*/

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

#include "common.h"

int main(int argc, char **argv)
{
    int i,j,k;
    int N;
    double *A;
    double l;
    double sec;

    FILE *fp = NULL;
```

```
    usage(argc, argv);
    /*
     * Allocate me!
     */
    fp = fopen(argv[1], "r");
    if(fp) {
        if(!fscanf(fp, "%d\n", &N)) {
            exit(EXIT_FAILURE);
        }
    }

    if((A = allocate_2d(N, N)) == NULL) {
        exit(EXIT_FAILURE);
    }
    if(parse_matrix_2d(fp, N, N, A) == NULL) {
        exit(EXIT_FAILURE);
    }


    sec = timer();
    for (k = 0; k < N - 1; k++)
    {
        for (i = k + 1; i < N; i++)
        {
            l = A[i * N + k] / A[k * N + k];
            for (j = k; j < N; j++)
            {
                A[i * N + j] = A[i * N + j] - l * A[k * N + j];
            }
        }
    }
    sec = timer();
    printf("Calc Time: %lf\n", sec);

    fp = fopen(argv[2], "w");
    fprint_matrix_2d(fp, N, N, A);
    fclose(fp);
    free(A);

    return 0;
}
```

Ζητούμενο 2 Παραλληλισμός Αλγορίθμου

Ο παραλληλισμος του αλγορίθμου εντοπίζεται στο γεγονός ότι υπάρχει ανεξαρτησία του υπολογισμού κατά γραμμές για δεδομένο k.





Ζητούμενο 3 Μοντέλο κοινού χώρου διευθύνσεων (OpenMP)

Ζητούμενο 4 Μοντέλο ανταλλαγής μηνυμάτων (MPI)

Ζητούμενο 4.1 Point to Point

```
/* -.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.
 * File Name : main.c
 * Creation Date : 30-10-2012
 * Last Modified : Sun 11 Nov 2012 06:40:33 PM EET
 * Created By : Greg Liras <gregliras@gmail.com>
 * Created By : Alex Maurogiannis <nalfemp@gmail.com>
 _.-._.-._.-._.-._.-._.-._.-._.-._.-._.-._.-._.-._.-._.-._.-._.-._.-.*/

#include <mpi.h>
#include <stdio.h>
#include <stdlib.h>
```

```c
#include <signal.h>
#include <signal.h>
#include <unistd.h>
#include <string.h>

#include "common.h"

#define BLOCK_ROWS 2


void process_rows(int k, int rank, int N, int max_rank, double *A){
    /*      performs the calculations for a given set of rows.
     *      In this hybrid version each thread is assigned blocks of
     *      continuous rows in a cyclic manner.
     */
    int i, j, w;
    double l;
    /* For every cyclic repetition of a block */
    for (i = (rank + ((BLOCK_ROWS * max_rank) * (k / (BLOCK_ROWS * max_rank)))); i < N ; i+=(max_rank * BLOCK_ROWS)) {
            if (i > k) {
                /* Calculate each continuous row in the block*/
                for (w = i; w < (i + BLOCK_ROWS) && w < (N * N); w++){
                    l = A[(w * N) + k] / A[(k * N) + k];
                    for (j = k; j < N; j++) {
                        A[(w * N) + j] = A[(w * N) + j] - l * A[(k* N) + j];
                    }
                }
            }
    }
}

int main(int argc, char **argv)
{
    int k;
    int N;
    int rank;
    int max_rank;
    int last_rank;
    double *A = NULL;
    double sec = 0;

    int ret = 0;
    FILE *fp = NULL;
    usage(argc, argv);

    MPI_Init(&argc, &argv);
    MPI_Comm_rank(MPI_COMM_WORLD, &rank);
    MPI_Comm_size(MPI_COMM_WORLD, &max_rank);

    if (rank == 0) {
        debug("rank: %d opens file: %s\n", rank, argv[1]);
        fp = fopen(argv[1], "r");
        if(fp) {
            if(!fscanf(fp, "%d\n", &N)) {
                MPI_Abort(MPI_COMM_WORLD, 1);
            }
        }
        else {
            MPI_Abort(MPI_COMM_WORLD, 1);
        }

    }

    MPI_Barrier(MPI_COMM_WORLD);
    propagate_with_flooding(&N, 1, MPI_INT, 0, MPI_COMM_WORLD);

    /* Everyone allocates the whole table */
    debug("Max rank = %d\n", max_rank);
    if((A = allocate_2d_with_padding(N, N, max_rank)) == NULL) {
        MPI_Abort(MPI_COMM_WORLD, 1);
    }
    /* Root Parses file */
    if (rank == 0) {
        if(parse_matrix_2d(fp, N, N, A) == NULL) {
            MPI_Abort(MPI_COMM_WORLD, 1);
```

```
        }
        fclose(fp);
        fp = NULL;
    }
    /* And distributes the table */
    MPI_Barrier(MPI_COMM_WORLD);
    propagate_with_flooding(A, N*N, MPI_DOUBLE, 0, MPI_COMM_WORLD);

    last_rank = (N - 1) % max_rank;

    if(rank == 0) {
        sec = timer();
    }

    for (k = 0; k < N - 1; k++) {
        /* The owner of the row for this k broadcasts it*/
        MPI_Barrier(MPI_COMM_WORLD);
        propagate_with_flooding(&A[k * N], N, MPI_DOUBLE, ((k % (max_rank * BLOCK_ROWS)) / BLOCK_ROWS), MPI_COMM_WORLD);

        process_rows(k, rank, N, max_rank, A);
    }

    MPI_Barrier(MPI_COMM_WORLD);
    if (rank == 0) {
        sec = timer();
        printf("Calc Time: %lf\n", sec);
    }
    ret = MPI_Finalize();

    if(ret == 0) {
        debug("%d FINALIZED!!! with code: %d\n", rank, ret);
    }
    else {
        debug("%d NOT FINALIZED!!! with code: %d\n", rank, ret);
    }

    /* Last process has table */
    if (rank == last_rank) {
        //print_matrix_2d(N, N, A);
        fp = fopen(argv[2], "w");
        fprint_matrix_2d(fp, N, N, A);
        fclose(fp);
    }
    free(A);

    return 0;
}
```

Ζητούμενο 4.2 Collective

```
/* -.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.-.
 * File Name : main.c
 * Creation Date : 30-10-2012
 * Last Modified : Thu 08 Nov 2012 09:49:47 AM EET
 * Created By : Greg Liras <gregliras@gmail.com>
 * Created By : Alex Maurogiannis <nalfemp@gmail.com>
 _.-._.-._.-._.-._.-._.-._.-._.-._.-._.-._.-._.-._.-._.-._.-._.-._.-.*/

#include <mpi.h>
#include <stdio.h>
#include <stdlib.h>
#include <signal.h>
#include <signal.h>
#include <unistd.h>
#include <string.h>

#include "common.h"

#define BLOCK_ROWS 2


void process_rows(int k, int rank, int N, int max_rank, double *A){
    /*      performs the calculations for a given set of rows.
     *      In this hybrid version each thread is assigned blocks of
     *      continuous rows in a cyclic manner.
```

```
     */
    int i, j, w;
    double l;
    /* For every cyclic repetition of a block */
    for (i = (rank + ((BLOCK_ROWS * max_rank) * (k / (BLOCK_ROWS * max_rank)))); i < N ; i+=(max_rank * BLOCK_ROWS)) {
            if (i > k) {
                /* Calculate each continuous row in the block*/
                for (w = i; w < (i + BLOCK_ROWS) && w < (N * N); w++){
                    l = A[(w * N) + k] / A[(k * N) + k];
                    for (j = k; j < N; j++) {
                        A[(w * N) + j] = A[(w * N) + j] - l * A[(k* N) + j];
                    }
                }
            }
    }
}

int main(int argc, char **argv)
{
    int k;
    int N;
    int rank;
    int max_rank;
    int last_rank;
    double *A = NULL;
    double sec = 0;

    int ret = 0;
    FILE *fp = NULL;
    usage(argc, argv);

    MPI_Init(&argc, &argv);
    MPI_Comm_rank(MPI_COMM_WORLD, &rank);
    MPI_Comm_size(MPI_COMM_WORLD, &max_rank);

    if (rank == 0) {
        debug("rank: %d opens file: %s\n", rank, argv[1]);
        fp = fopen(argv[1], "r");
        if(fp) {
            if(!fscanf(fp, "%d\n", &N)) {
                MPI_Abort(MPI_COMM_WORLD, 1);
            }
        }
        else {
            MPI_Abort(MPI_COMM_WORLD, 1);
        }

    }

    MPI_Barrier(MPI_COMM_WORLD);
    MPI_Bcast(&N, 1, MPI_INT, 0, MPI_COMM_WORLD);

    /* Everyone allocates the whole table */
    debug("Max rank = %d\n", max_rank);
    if((A = allocate_2d_with_padding(N, N, max_rank)) == NULL) {
        MPI_Abort(MPI_COMM_WORLD, 1);
    }
    /* Root Parses file */
    if (rank == 0) {
        if(parse_matrix_2d(fp, N, N, A) == NULL) {
            MPI_Abort(MPI_COMM_WORLD, 1);
        }
        fclose(fp);
        fp = NULL;
    }
    /* And distributes the table */
    MPI_Barrier(MPI_COMM_WORLD);
    MPI_Bcast(A, N*N, MPI_DOUBLE, 0, MPI_COMM_WORLD);

    last_rank = (N - 1) % max_rank;

    if(rank == 0) {
        sec = timer();
    }

```

```
    for (k = 0; k < N - 1; k++) {
        /* The owner of the row for this k broadcasts it*/
        MPI_Barrier(MPI_COMM_WORLD);
        MPI_Bcast(&A[k * N], N, MPI_DOUBLE, ((k % (max_rank * BLOCK_ROWS)) / BLOCK_ROWS), MPI_COMM_WORLD);

        process_rows(k, rank, N, max_rank, A);
    }

    MPI_Barrier(MPI_COMM_WORLD);
    if (rank == 0) {
        sec = timer();
        printf("Calc Time: %lf\n", sec);
    }
    ret = MPI_Finalize();

    if(ret == 0) {
        debug("%d FINALIZED!!! with code: %d\n", rank, ret);
    }
    else {
        debug("%d NOT FINALIZED!!! with code: %d\n", rank, ret);
    }

    /* Last process has table */
    if (rank == last_rank) {
        //print_matrix_2d(N, N, A);
        fp = fopen(argv[2], "w");
        fprint_matrix_2d(fp, N, N, A);
        fclose(fp);
    }
    free(A);

    return 0;
}
```