-Assignment 7-
Preventing Starvation of Philosophers while Dining and Thinking

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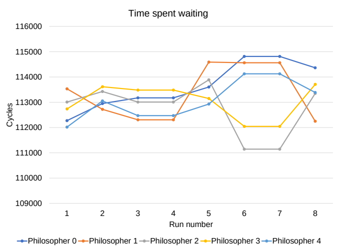
1 Basic Algorithm

The dining problem is handled using the following basic psuedo code:

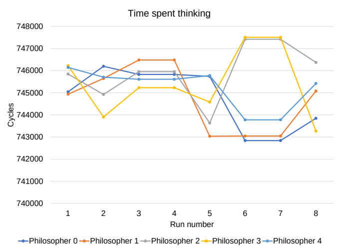
- At least one of the philosopher is hungry:
  - Iterate over all the hungry philosophers in random order
    - If both left and right chopsticks are available for the philosopher then allow the philosopher to eat.
    - Else, the philosopher waits till the chopsticks are available
- Else, continue on since no one is hungry

The idea that the hungry philosopher is randomly selected for checking the availability of chopsticks ensures that no philosopher is starved.

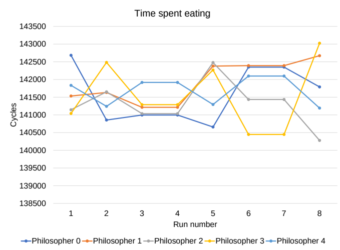
2 Results



(a) Line chart showing the number of cycles for which a philosopher was hungry during simulation across 7 runs.



(b) Line chart showing the number of cycles for which a philosopher was hungry (that is waiting for atleast of the two adjacent chopsticks to be free) during simulation across 7 runs.



(c) Line chart showing the number of cycles for which a philosopher was eating during simulation across 7 runs.

The problem was written in C and simulated by progressing in steps (called ticks), total 7 simulations were performed where each one of them was simulated for 1000000 time quantums (cycles). 5 philosophers were simulated where each philosopher had a probability of getting hungry while thinking of 0.05 and probability of going back to thinking from eating of 0.75 at each cycle. The philosophers had 3 states:

1. `HUNGRY`: When a philosopher is waiting for chopsticks.

2. EATING: When a philosopher has acquired two chopsticks and is eating.

3. THINKING: When a philosopher is thinking.

Result: The results clearly show that none of the philosophers are at an advantage compared to the other and no condition of deadlock arises.

3 Code

```
#include <stdio.h>
#include <math.h>
#include <stdlib.h>
#include <time.h>

const int MAX_TICKS = 1000000;
const int PHILOSOPHER_COUNT = 5;
const int HUNGER_PROBABILITY_MAX = 100;
const int HUNGER_PROBABILITY = 5; /* Out of HUNGER_PROBABILITY_MAX */
const int EATING_PROBABILITY_MAX = 100;
const int EATING_PROBABILITY = 75; /* Out of EATING_PROBABILITY_MAX */

/* Represents the state of a philosopher */
typedef enum phil_state {
    EATING,
    THINKING,
    HUNGRY,
    MAX_PS
} phil_state_t;

/* Represents the state of a chopstick */
typedef enum cs_state {
    BUSY,
    AVAILABLE,
    MAX_CS
} cs_state_t;

/* Represents a philosopher and associated variables */
typedef struct philosopher {
    int id;
    phil_state_t lastState = THINKING;
    phil_state_t state = THINKING;
} philosopher_t;

/* Represents a chopstick and associated variables */
typedef struct chopstick {
    int id;
    cs_state_t state = AVAILABLE;
} chopstick_t;

/* Represents the table on which the philosophers dine together */
typedef struct table {
    philosopher_t *philosophers;
    chopstick_t *chopsticks;
```

```
} table_t;

/* Holds statistics of philosopher's different states as an array */
typedef struct stat {
    long int type[MAX_PS];
} stat_t;

/*****************************************************************/
/*      Functions for randomly iterating over the philosophers      */
int l_max, l_index, l_offset;
void l_init(int start, int max) {
    l_max = max;
    l_index = start;
    l_offset = rand()%l_max;
}

int l_getCurrentValue() {
    return ((long) l_index * 3 + l_offset) % (l_max);
}

int l_hasNext() {
    return l_index < l_max;
}

int l_next() {
    int answer = l_getCurrentValue();
    l_index++;
    return answer;
}
/*****************************************************************/

/* Each call to this function will increase the time by a single tick
 * The function also manages all the philosophers */
long int ticks;
long int tick(table_t *table, long int &ticks, stat_t *philosopherStats) {

    ticks++;
    for (int phil = 0; phil < PHILOSOPHER_COUNT; phil++) {
        /* Philosophers are hungry if the generated random number is
           greater than HUNGER_PROBABILITY */
        if (table->philosophers[phil].state == THINKING) {
            phil_state_t newState = (rand()%HUNGER_PROBABILITY_MAX > HUNGER_PROBABILITY)
                ? THINKING : HUNGRY;
            table->philosophers[phil].state = newState;
        } else if (table->philosophers[phil].state == EATING) {
            phil_state_t newState = (rand()%EATING_PROBABILITY_MAX > EATING_PROBABILITY)
                ? THINKING : EATING;
            if (newState == THINKING) {
                table->philosophers[phil].state = newState;

                int right_cs = phil;
                int left_cs = (phil+PHILOSOPHER_COUNT-1)%PHILOSOPHER_COUNT;
                table->chopsticks[left_cs].state  = AVAILABLE;
```

```c
                table->chopsticks[right_cs].state = AVAILABLE;
            }
        }
    }

    /* Manage the philosophers */
    l_init(0, PHILOSOPHER_COUNT);
    int phil = 0;
    do {
        phil=l_next();
        printf("phil: %d", phil);
        /* Update the stats */
        philosopherStats[phil].type[table->philosophers[phil].state]++;

        if (table->philosophers[phil].state == HUNGRY) {
            int right_phil = phil+1;
            int left_phil = (phil+PHILOSOPHER_COUNT-1)%PHILOSOPHER_COUNT;

            int right_cs = phil;
            int left_cs = (phil+PHILOSOPHER_COUNT-1)%PHILOSOPHER_COUNT;

            /* Check if the philosopher's chopsticks are available */
            if ((table->chopsticks[left_cs].state == AVAILABLE)
                && (table->chopsticks[right_cs].state == AVAILABLE)) {

                /* If the philosopher's neighbours aren't waiting
                   let's change the state to EATING */
                table->philosophers[phil].state = EATING;

                table->chopsticks[left_cs].state  = BUSY;
                table->chopsticks[right_cs].state = BUSY;
            }
        }
    } while (l_hasNext());
}

/* Prints the representation of the table passed */
void print_table(table_t *table, int philosopher_count = PHILOSOPHER_COUNT) {
    for (int i = 0; i < PHILOSOPHER_COUNT; i++) {
        switch (table->philosophers[i].state) {
        case THINKING:{
            printf("T");
            break;
        }
        case HUNGRY: {
            printf("H");
            break;
        }
        case EATING: {
            printf("E");
            break;
        }
        }
```

```
        printf("%c", table->chopsticks[i].state == BUSY ? '.' : '|');
    }
    printf("\n");
}

/* A function for logging to stdout */
void update_trace(table_t *table, long int &ticks) {
    printf("%04ld: ", ticks);
    print_table(table);
}

/* Prints the stats to the stdout in form of a table */
void print_stats(stat_t *stats) {
    printf("%4s: %6s %6s %6s\n", "id", "eat", "think", "hungry");
    for (int phil = 0; phil < PHILOSOPHER_COUNT; phil++) {
         printf("%4d: %6ld %6ld %6ld\n",
                phil,
                stats[phil].type[0],
                stats[phil].type[1],
                stats[phil].type[2]);
    }
}

/* Main function */
int main() {
    srand(time(NULL));

    stat_t *philosopherStats;
    philosopherStats = (stat*)malloc(sizeof(stat_t)*PHILOSOPHER_COUNT);

    /* Initialize the table */
    table_t *table = (table_t*)malloc(sizeof(table_t));

    table->philosophers = (philosopher_t*)malloc(sizeof(philosopher_t)*PHILOSOPHER_COUNT);
    for (int phil = 0; phil < PHILOSOPHER_COUNT; phil++) {
        table->philosophers[phil].id = phil;
        table->philosophers[phil].state = THINKING;
    }

    table->chopsticks = (chopstick_t*)malloc(sizeof(chopstick_t)*PHILOSOPHER_COUNT);
    for (int cs = 0; cs < PHILOSOPHER_COUNT; cs++) {
        table->chopsticks[cs].id = cs;
        table->chopsticks[cs].state = AVAILABLE;
    }
    printf("Starting simulation...\n");

    int count = 0;
    while (count++ < MAX_TICKS) {
        update_trace(table, ticks);
        tick(table, ticks, philosopherStats);
    }
    printf("\nStats...\n");
    print_stats(philosopherStats);
```

```
}
```

3.1 Sample Execution Result

```
Starting simulation...
0000: T|T|T|T|T|
0001: T|T|T|T|T|
0002: T|T|T|T|T|
0003: T|T|T|T|T|
0004: T|T|T|T.E.
0005: T|T|T|T.E.
0006: T|T|T|T|T|
0007: E.T.E.T|T.
0008: E.T.E.T|T.
0009: E.T.E.T|T.

Stats...
  id:    eat  think hungry
   0:      2      7      1
   1:      0     10      0
   2:      3      6      1
   3:      0     10      0
   4:      1      8      1
```