



# Tecnológico de Monterrey

**Tecnológico de Monterrey  
(Campus Guadalajara)**

**Ingeniería en Robótica y Sistemas Digitales (IRS)**

Diseño de sistemas embebidos avanzados

[TC 2036 Grupo 501](#)

## **Actividad 3**

Optimization of air condition system in  
an industrial unit.

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**Fecha:**

05 de noviembre de 2022

Makefile:

Compilar: gcc heat.c -o heat -fopenmp -lpthread -lm

Correr: time ./heat "threads"

Programa con diferentes threads:

Primera nota: cuando uso 1 thread por lo general me da -1 en todos los valores no entiendo el por que ocurre esto investigue pero no se mostraba nada

2 threads:

```
root@LAPTOP-C00E73NC:~# time ./heat 2
Matrix Data:
C C C C C C C
C C C C C C C
C C H H H C C
C C H H H C C
C C H H H C C
C C C C C C C
Matrix temperature:
5 16 26 38 32 21 12
57 34 0 2 18 40 26
52 7 81 71 89 31 46
40 48 82 92 63 39 35
54 1 61 93 95 31 49
31 14 46 32 30 15 11

Dear manager:
This is the heat equation for the factory:

$$Q = 2 * (0.125 / (1)^2)$$

```

4 threads:

```

root@LAPTOP-C00E73NC:~# time ./heat 4
Matrix Data:
C C C C C C C
C C C C C C C
C C H H H C C
C C H H H C C
C C H H H C C
C C C C C C C
Matrix temperature:
3 9 38 20 38 15 14
13 6 3 32 52 29 16
45 28 95 91 81 31 59
11 10 77 71 93 24 41
4 24 72 85 82 26 33
53 36 30 24 18 1 29

Dear manager:
This is the heat equation for the factory:
 $Q = 2 * (0.125 / (1)^2)$ 

real    0m0,003s
user    0m0,006s
sys     0m0,001s

```

8 threads:

```

root@LAPTOP-C00E73NC:~# time ./heat 8
Matrix Data:
C C C C C C C
C C C C C C C
C C H H H C C
C C H H H C C
C C H H H C C
C C C C C C C
Matrix temperature:
50 23 12 50 14 43 9
60 2 34 42 12 54 31
33 47 86 71 85 37 17
9 18 87 99 91 17 1
28 32 62 97 99 35 43
33 31 38 37 21 37 36

Dear manager:
This is the heat equation for the factory:
 $Q = 2 * (0.125 / (1)^2)$ 

real    0m0,005s
user    0m0,000s
sys     0m0,004s
root@LAPTOP-C00E73NC:~#

```

10 threads:

```

root@LAPTOP-C00E73NC:~# time ./heat 10
Matrix Data:
C C C C C C C
C C C C C C C
C C H H H C C
C C H H H C C
C C H H H C C
C C C C C C C
Matrix temperature:
18 16 56 33 58 9 23
51 58 6 46 9 46 49
35 1 80 90 72 43 13
46 31 82 70 85 57 42
41 26 94 98 90 28 43
43 36 39 0 17 8 42

Dear manager:
This is the heat equation for the factory:

$$Q = 2 * (0.125 / (1)^2)$$


real    0m0,005s
user    0m0,000s
sys     0m0,006s
root@LAPTOP-C00E73NC:~#

```

20 threads:

```

root@LAPTOP-C00E73NC:~# time ./heat 20
Matrix Data:
C C C C C C C
C C C C C C C
C C H H H C C
C C H H H C C
C C H H H C C
C C C C C C C
Matrix temperature:
51 12 55 13 15 9 32
47 2 30 40 13 5 39
25 60 62 76 89 47 16
0 45 73 72 67 13 25
41 27 82 62 69 2 40
25 41 12 55 59 36 51

Dear manager:
This is the heat equation for the factory:

$$Q = 2 * (0.125 / (1)^2)$$


real    0m0,005s
user    0m0,003s
sys     0m0,003s

```

Recursos del sistema utilizados para n threads:

2 threads:

```
0[          0.0%] 3[          0.0%] 6[          0.7%] 9[          0.0%]
1[          0.0%] 4[          0.7%] 7[          0.0%] 10[         0.0%]
2[          0.7%] 5[          0.0%] 8[          0.0%] 11[         0.0%]
Mem[||||]
106M/12.3G Tasks: 8, 1 thr; 1 running
0K/4.00G Load average: 0.00 0.00 0.00
Uptime: 00:09:05

  PID USER   PRI  NI  VIRT   RES   SHR  S  CPU% MEM%   TIME+  Command
    3 root    20    0  1356    380    20  S   0.7  0.0  0:00.06 /init
    1 root    20    0   920    536   468  S   0.0  0.0  0:00.03 /init
    7 root    20    0   920    536   468  S   0.0  0.0  0:00.00 /init
    2 root    20    0  1356    380    20  S   0.0  0.0  0:00.00 /init
    4 root    20    0 11396   5432  3676  S   0.0  0.0  0:00.04 -bash
    1 root    20    0  1268    376    20  S   0.0  0.0  0:00.00 /init
    2 root    20    0  1268    376    20  S   0.0  0.0  0:00.03 /init
    3 root    20    0 11396   5364  3708  S   0.0  0.0  0:00.01 -bash
    9 root    20    0 10600   3952  3316  R   0.0  0.0  0:00.13 htop

elp F2Setup F3Search F4Filter F5Tree F6SortBy F7Nice F8Nice F9Kill F10Quit
```

4 threads:

```
161 180
165 190
210 210
245 245

0[          0.0%] 3[          0.0%] 6[          0.0%] 9[          0.0%]
1[          0.0%] 4[          0.0%] 7[          0.0%] 10[         0.0%]
2[          0.0%] 5[          0.0%] 8[          0.0%] 11[         0.0%]
Mem[||||]
104M/12.3G Tasks: 8, 1 thr; 1 running
0K/4.00G Load average: 0.02 0.01 0.00
Uptime: 00:01:39

  PID USER   PRI  NI  VIRT   RES   SHR  S  CPU% MEM%   TIME+  Command
    1 root    20    0   920    536   468  S   0.0  0.0  0:00.03 /init
    7 root    20    0   920    536   468  S   0.0  0.0  0:00.00 /init
   12 root    20    0  1356    380    20  S   0.0  0.0  0:00.00 /init
   13 root    20    0  1356    380    20  S   0.0  0.0  0:00.00 /init
   14 root    20    0 11396   5428  3676  S   0.0  0.0  0:00.02 -bash
   51 root    20    0  1268    376    20  S   0.0  0.0  0:00.00 /init
   52 root    20    0  1268    376    20  S   0.0  0.0  0:00.00 /init
   53 root    20    0 11396   5364  3708  S   0.0  0.0  0:00.01 -bash
   69 root    20    0 10600   3952  3316  R   0.0  0.0  0:00.01 htop
```

8 threads:

```
root@LAPTOP-C00E73NC: ~  
0[ 0.0%] 3[ 0.0%] 6[ 0.7%] 9[ 0.0%]  
1[ 0.7%] 4[ 0.7%] 7[ 0.0%] 10[ 0.7%]  
2[ 0.0%] 5[ 0.7%] 8[ 0.7%] 11[ 0.0%]  
m[ ] 107M/12.3G Tasks: 8, 1 thr; 1 running  
p[ ] 0K/4.00G Load average: 0.00 0.00 0.00  
Uptime: 00:10:05  
D USER PRI NI VIRT RES SHR S CPU% MEM% TIME+ Command  
9 root 20 0 10600 3952 3316 R 0.7 0.0 0:00.15 htop  
1 root 20 0 920 536 468 S 0.0 0.0 0:00.03 /init  
7 root 20 0 920 536 468 S 0.0 0.0 0:00.00 /init  
2 root 20 0 1356 380 20 S 0.0 0.0 0:00.00 /init  
3 root 20 0 1356 380 20 S 0.0 0.0 0:00.07 /init  
4 root 20 0 11396 5432 3676 S 0.0 0.0 0:00.04 -bash  
1 root 20 0 1268 376 20 S 0.0 0.0 0:00.00 /init  
2 root 20 0 1268 376 20 S 0.0 0.0 0:00.03 /init  
3 root 20 0 11396 5364 3708 S 0.0 0.0 0:00.01 -bash  
Help F2Setup F3Search F4Filter F5Tree F6SortBy F7Nice -F8Nice +F9Kill F10Quit
```

10 threads:

```
root@LAPTOP-C00E73NC: ~  
0[ 0.0%] 3[ 0.0%] 6[ 0.0%] 9[ 0.0%]  
1[ 0.7%] 4[ 0.7%] 7[ 0.7%] 10[ 0.0%]  
2[ 0.0%] 5[ 0.7%] 8[ 0.0%] 11[ 0.0%]  
m[ ] 107M/12.3G Tasks: 8, 1 thr; 1 running  
p[ ] 0K/4.00G Load average: 0.00 0.00 0.00  
Uptime: 00:10:32  
D USER PRI NI VIRT RES SHR S CPU% MEM% TIME+ Command  
3 root 20 0 1356 380 20 S 0.7 0.0 0:00.08 /init  
4 root 20 0 11396 5432 3676 S 0.7 0.0 0:00.05 -bash  
1 root 20 0 920 536 468 S 0.0 0.0 0:00.03 /init  
7 root 20 0 920 536 468 S 0.0 0.0 0:00.00 /init  
2 root 20 0 1356 380 20 S 0.0 0.0 0:00.00 /init  
1 root 20 0 1268 376 20 S 0.0 0.0 0:00.00 /init  
2 root 20 0 1268 376 20 S 0.0 0.0 0:00.03 /init  
3 root 20 0 11396 5364 3708 S 0.0 0.0 0:00.01 -bash  
9 root 20 0 10600 3952 3316 R 0.0 0.0 0:00.15 htop  
Help F2Setup F3Search F4Filter F5Tree F6SortBy F7Nice -F8Nice +F9Kill F10Quit
```

20 threads:

```

root@LAPTOP-C00E73NC: ~
0[ 0.7%] 3[ 0.0%] 6[ 0.0%] 9[ 0.0%]
1[ 0.7%] 4[ 0.7%] 7[ 0.0%] 10[ 0.0%]
2[ 0.0%] 5[ 0.0%] 8[ 0.0%] 11[ 0.0%]
m[||||] 107M/12.3G Tasks: 8, 1 thr; 1 running
p[ 0K/4.00G Load average: 0.00 0.00 0.00
Uptime: 00:11:02

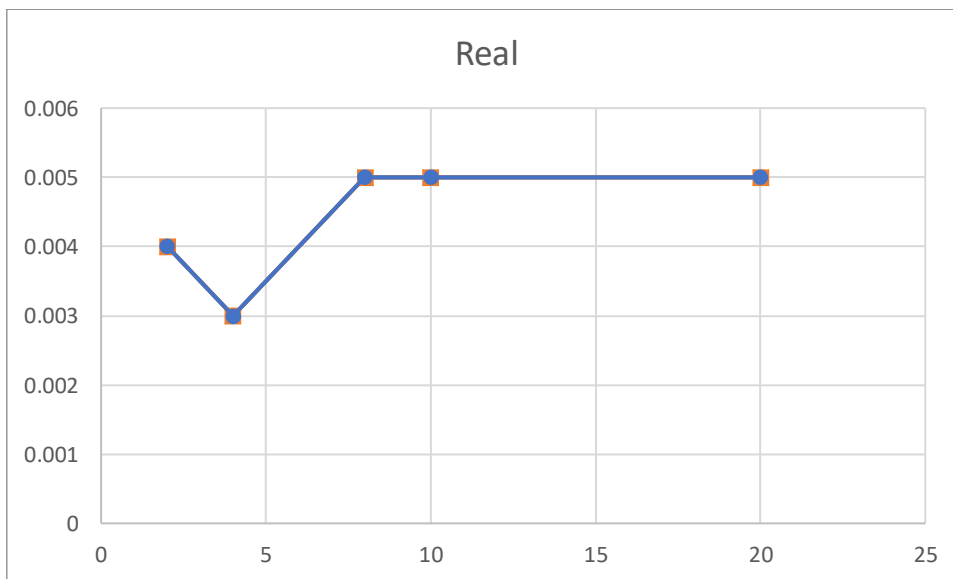
D USER PRI NI VIRT RES SHR S CPU% MEM% TIME+ Command
3 root 20 0 1356 380 20 S 0.7 0.0 0:00.09 /init
1 root 20 0 920 536 468 S 0.0 0.0 0:00.03 /init
7 root 20 0 920 536 468 S 0.0 0.0 0:00.00 /init
2 root 20 0 1356 380 20 S 0.0 0.0 0:00.00 /init
4 root 20 0 11396 5432 3676 S 0.0 0.0 0:00.05 -bash
1 root 20 0 1268 376 20 S 0.0 0.0 0:00.00 /init
2 root 20 0 1268 376 20 S 0.0 0.0 0:00.03 /init
3 root 20 0 11396 5364 3708 S 0.0 0.0 0:00.01 -bash
9 root 20 0 10600 3952 3316 R 0.0 0.0 0:00.16 htop

help F2Setup F3Search F4Filter F5Tree F6SortBy F7Nice F8Nice F9Kill F10Quit

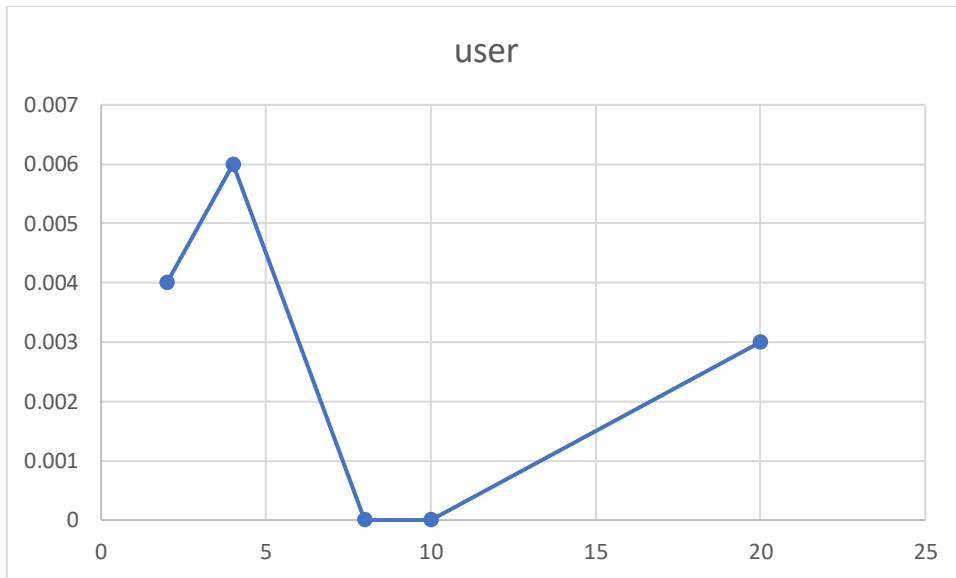
```

Graficas de tiempo respecto a la ejecución:

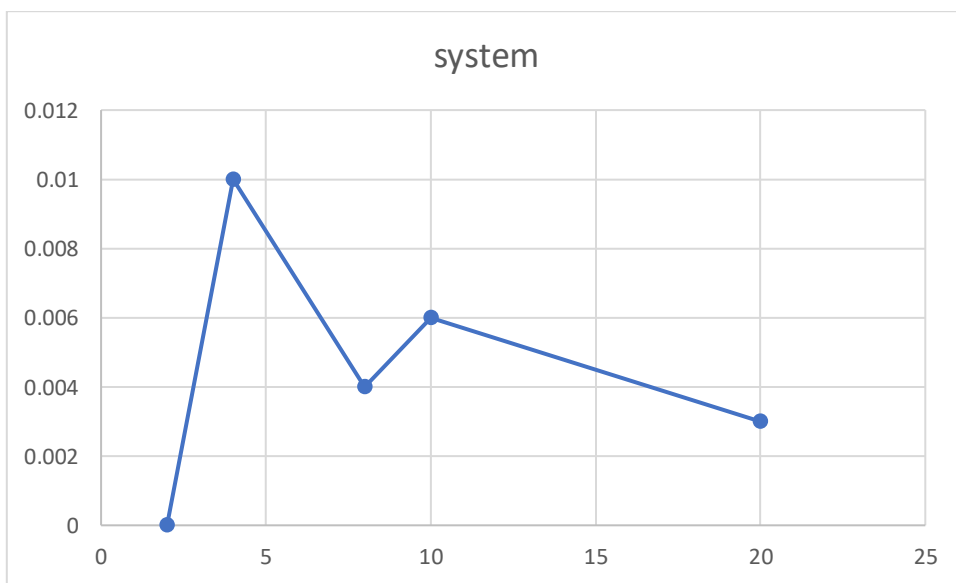
Grafica de tiempo real respecto a threads:



Grafica de tiempo de user respecto a threads:

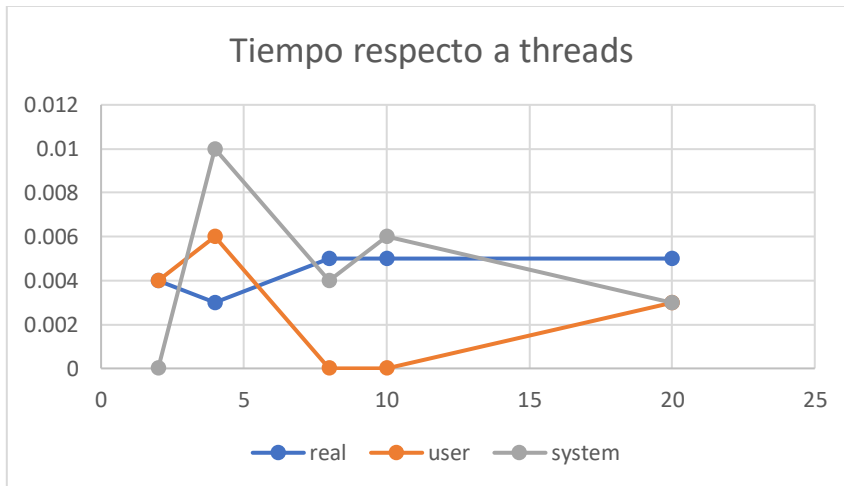


Grafica de tiempo de sistema respecto a threads:

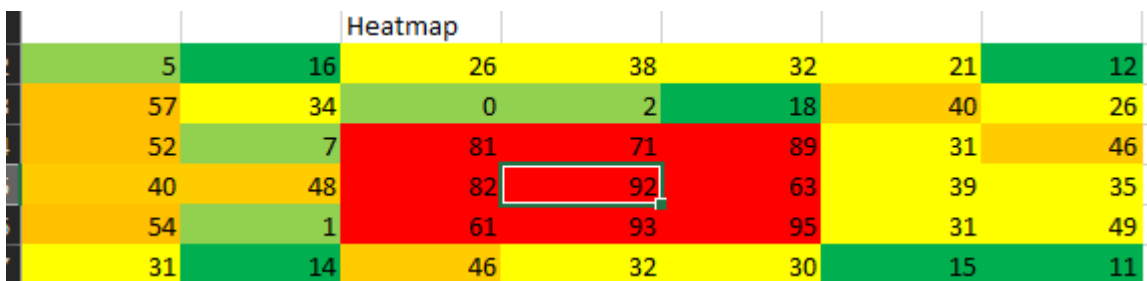


Comparativa de todos los tiempos:





Heat map:



Conclusión: una actividad que sirvió como cierre para dar por finalizado el curso la cual fue bastante retadora, sobre todo la parte de usar los threads para tomar los datos de la matriz, me sirvió para indagar un poco mas en los threads al verme en la necesidad de ver varios libros y videos para realizar esta actividad, aunque no logre que leerá un archivo cvs que era el principal reto, me llevo la experiencia para poder ponérmela como reto mas adelante, el que lograra arrojarme los valores dependiendo la letra aunque no fue difícil si estuvo confuso puesto que al principio no lograba que me diera los valores correctos, me llevo lo mejor y considero que fue un gran acercamiento al uso de threadas para la solución de problemas.

Referencias:

<https://levelup.gitconnected.com/solving-2d-heat-equation-numerically-using-python-3334004aa01a>

<https://github.com/VictorRodriguez/parallel-programming-lecture/blob/main/labs/04/simple-thread.c>

[https://github.com/VictorRodriguez/parallel-programming-lecture/blob/main/labs/07/trapezoidal\\_omp\\_2.c](https://github.com/VictorRodriguez/parallel-programming-lecture/blob/main/labs/07/trapezoidal_omp_2.c)

<https://www.youtube.com/watch?v=7NT75rzig3TQ>