HW5

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What have you done

1. 使用 **MPI+OpenMP** 實作
   每一台電腦各啟動一個 process，每個 process 再 fork 出 4 條 thread，電腦數量可自訂。
2. Roulette Wheel Selection
   實作於

```
int random_city(vector<int> &P,vector<bool> &Sp)
```

3. 共享費洛蒙，openmp tid 0,1,2,3 每 3 round 平均費洛蒙，而 mpi 的兩個 host 每 6 round 平均費洛蒙。
4. 在一個主機中，4 個蟻巢(thread)進行錯位加總。

```
int ring=tid;//4 個蟻巢進行錯位加總
do{
    for(int i=ring;i<N;i+=4){
        for(int j=0;j<N;j++){
            global_pheromone[i][j]+=pheromone[i][j]/4;
        }
    }
    ring=(ring+1)%4;
    #pragma omp barrier//等待該 ring 結束
}while(ring!=tid);
```

   如果大家都一起把自己的費洛蒙加在同個地方，需要有 critical session，所以，tid=0,1,2,3 就先把值加在除以四餘數為 0,1,2,3 的排，等一大家都好了，再加到 1,2,3,0，直到每個 thread 每個餘數的排都加過。
5. Bonus
   每個蟻巢持續記錄自己的最小值，再將自己的最小值更新到(如果更小)全域(同一台電腦)最小值，再用 MPI 丟到 rank =0 ，印出所有蟻巢最小值。

Analysis on your result

環境: (老師的伺服器)

```
F74081129@pn1:~/hw6> cat ~/mpd.hosts
pn1:1
pn2:1
```

編譯:

```
mpiicpc h6_problem1.cpp -o h6_problem1.out -std=c++0x -openmp -lm
```

測資放在 ~/hw6/res/
程式放在 ~/hw6/，所以工作資料夾在 ~/hw6/
所以記得要先 cd ~/hw6/，然後編譯，再 ./h6_problem1.out ./res/測資 txt
也可以把測資搬到 ./hw6/ 底下，然後 ./h6_problem1.out ./測資 txt

測試收斂速度:以 att48_d.txt 為例

一台電腦

```
F74081129@pn1:~/hw6> mpiexec -machinefile ~/mpd.hosts -n 1 ./h6_problem1.out ./res/att48_d.txt -r 10
pn1
Filename is ./res/att48_d.txt
The min length of cycle is 80497
The cycle with min length is:
12 -> 33 -> 22 -> 10 -> 14 -> 23 -> 44 -> 34 -> 25 -> 3 -> 41 -> 47 -> 24 -> 19 -> 26 -> 42 -> 18 -> 29 -> 37 -> 2
0 -> 11 -> 30 -> 43 -> 7 -> 39 -> 40 -> 46 -> 13 -> 2 -> 16 -> 35 -> 27 -> 0 -> 15 -> 8 -> 6 -> 36 -> 5 -> 45 -> 3
1 -> 38 -> 4 -> 28 -> 9 -> 1 -> 32 -> 17 -> 21 -> 12
F74081129@pn1:~/hw6> mpiexec -machinefile ~/mpd.hosts -n 1 ./h6_problem1.out ./res/att48_d.txt -r 20
pn1
Filename is ./res/att48_d.txt
The min length of cycle is 77311
The cycle with min length is:
34 -> 4 -> 22 -> 7 -> 8 -> 0 -> 30 -> 37 -> 41 -> 33 -> 15 -> 12 -> 21 -> 2 -> 39 -> 10 -> 43 -> 14 -> 32 -> 11 ->
 46 -> 40 -> 9 -> 35 -> 45 -> 17 -> 42 -> 5 -> 27 -> 29 -> 36 -> 18 -> 6 -> 26 -> 16 -> 19 -> 20 -> 31 -> 13 -> 28
 -> 24 -> 38 -> 47 -> 25 -> 3 -> 1 -> 23 -> 44 -> 34
F74081129@pn1:~/hw6> mpiexec -machinefile ~/mpd.hosts -n 1 ./h6_problem1.out ./res/att48_d.txt -r 40
pn1
Filename is ./res/att48_d.txt
The min length of cycle is 41524
The cycle with min length is:
44 -> 25 -> 3 -> 41 -> 9 -> 23 -> 31 -> 38 -> 47 -> 4 -> 28 -> 1 -> 13 -> 24 -> 12 -> 22 -> 20 -> 46 -> 10 -> 11 -
> 32 -> 45 -> 30 -> 43 -> 17 -> 6 -> 35 -> 27 -> 5 -> 29 -> 36 -> 18 -> 26 -> 16 -> 42 -> 19 -> 14 -> 37 -> 8 -> 7
 -> 0 -> 39 -> 2 -> 21 -> 15 -> 40 -> 33 -> 34 -> 44
```

40 round 收斂到 41524

兩台電腦

```
F74081129@pn1:~/hw6> mpiexec -machinefile ~/mpd.hosts -n 2 ./h6_problem1.out ./res/att48_d.txt -r 10
pn2
pn1
Filename is ./res/att48_d.txt
The min length of cycle is 80655
The cycle with min length is:
41 -> 4 -> 2 -> 21 -> 15 -> 24 -> 31 -> 19 -> 28 -> 1 -> 34 -> 9 -> 23 -> 38 -> 20 -> 37 -> 39 -> 11 -> 14 -> 45 -
> 10 -> 22 -> 42 -> 18 -> 36 -> 29 -> 17 -> 27 -> 5 -> 26 -> 32 -> 6 -> 0 -> 8 -> 35 -> 43 -> 30 -> 16 -> 47 -> 40
 -> 25 -> 3 -> 44 -> 46 -> 7 -> 33 -> 13 -> 12 -> 41
F74081129@pn1:~/hw6> mpiexec -machinefile ~/mpd.hosts -n 2 ./h6_problem1.out ./res/att48_d.txt -r 20
pn1
pn2
Filename is ./res/att48_d.txt
The min length of cycle is 71174
The cycle with min length is:
11 -> 39 -> 46 -> 30 -> 43 -> 2 -> 25 -> 41 -> 23 -> 31 -> 38 -> 47 -> 28 -> 1 -> 4 -> 13 -> 35 -> 27 -> 6 -> 17 -
> 16 -> 42 -> 29 -> 26 -> 18 -> 36 -> 5 -> 24 -> 40 -> 14 -> 21 -> 12 -> 20 -> 19 -> 45 -> 32 -> 8 -> 37 -> 7 -> 1
0 -> 22 -> 0 -> 15 -> 33 -> 9 -> 34 -> 44 -> 3 -> 11
F74081129@pn1:~/hw6> mpiexec -machinefile ~/mpd.hosts -n 2 ./h6_problem1.out ./res/att48_d.txt -r 40
pn2
pn1
Filename is ./res/att48_d.txt
The min length of cycle is 40923
The cycle with min length is:
42 -> 16 -> 29 -> 5 -> 36 -> 18 -> 26 -> 6 -> 27 -> 32 -> 45 -> 14 -> 11 -> 19 -> 43 -> 30 -> 37 -> 7 -> 8 -> 0 ->
 21 -> 2 -> 15 -> 40 -> 33 -> 13 -> 24 -> 38 -> 47 -> 4 -> 28 -> 1 -> 3 -> 25 -> 9 -> 44 -> 34 -> 41 -> 23 -> 31 -
> 12 -> 20 -> 46 -> 10 -> 22 -> 39 -> 35 -> 17 -> 42
```

40 round 收斂到 40923

這個結果算是意料之內，畢竟是機率演算法，我的每個蟻巢有 60 隻螞蟻，而 4 條 thread 就是每台電腦有 240 隻螞蟻，2 台電腦大概就是 240 和 480 隻螞蟻的差別(只能說大概，因為電腦每 6 回合才取平均)，480 隻收斂一定快一些，至於這個差別有多大，交給統計學專家就好。

注意，因為 rand() 非 thread safe，所以 openmp 分出來 thread 共享同意亂數數列，讓程式每次結果都不同。

參數介紹:

參數	介紹	默認
-r	(int) round	80
-a	(float) alpha	1.1
-b	(float) beta	0.8
-e	(float) 蒸發率	0.23
-m	(int) 每個蟻巢的螞蟻數量	60

修改 alpha beta:

```
F74081129@pn1:~/hw6> mpiexec -machinefile ~/mpd.hosts -n 2 ./h6_problem1.out ./res/att48_d.txt -a 2.2 -b 1.6 -r 10
pn2
pn1
Filename is ./res/att48_d.txt
The min length of cycle is 53711
The cycle with min length is:
20 -> 19 -> 32 -> 26 -> 18 -> 36 -> 5 -> 29 -> 16 -> 42 -> 27 -> 35 -> 6 -> 17 -> 43 -> 12 -> 10 -> 14 -> 39 -> 22
 -> 13 -> 24 -> 31 -> 38 -> 33 -> 2 -> 40 -> 15 -> 21 -> 0 -> 7 -> 37 -> 45 -> 11 -> 4 -> 47 -> 9 -> 41 -> 3 -> 25
 -> 34 -> 44 -> 23 -> 28 -> 1 -> 46 -> 30 -> 8 -> 20
F74081129@pn1:~/hw6> mpiexec -machinefile ~/mpd.hosts -n 2 ./h6_problem1.out ./res/att48_d.txt -a 1.1 -b 0.8 -r 10
pn2
pn1
Filename is ./res/att48_d.txt
The min length of cycle is 78555
The cycle with min length is:
23 -> 38 -> 17 -> 35 -> 6 -> 29 -> 45 -> 30 -> 39 -> 20 -> 5 -> 18 -> 16 -> 36 -> 26 -> 42 -> 14 -> 13 -> 40 -> 33
 -> 47 -> 11 -> 10 -> 24 -> 4 -> 1 -> 31 -> 12 -> 21 -> 22 -> 2 -> 0 -> 8 -> 37 -> 46 -> 15 -> 32 -> 19 -> 27 -> 4
3 -> 7 -> 25 -> 9 -> 28 -> 41 -> 34 -> 44 -> 3 -> 23
```

Alpha beta 越大，越容易收斂，但是也容易收斂到 local minimal。

較小的測資 local minimal 不多，可以採快速收斂，容易得到 global minimum。

```
F74081129@pn1:~/hw6> mpiexec -machinefile ~/mpd.hosts -n 2 ./h6_problem1.out ./res/fri26_d.txt
pn1
pn2
Filename is ./res/fri26_d.txt
The min length of cycle is 937
The cycle with min length is:
5 -> 4 -> 6 -> 7 -> 8 -> 9 -> 13 -> 14 -> 12 -> 11 -> 10 -> 15 -> 18 -> 19 -> 17 -> 16 -> 20 -> 21 -> 25 -> 22 ->
23 -> 24 -> 0 -> 1 -> 2 -> 3 -> 5
F74081129@pn1:~/hw6> mpiexec -machinefile ~/mpd.hosts -n 2 ./h6_problem1.out ./res/
att48_d.txt      dantzig42_d.txt  fri26_d.txt      gr17_d.txt
F74081129@pn1:~/hw6> mpiexec -machinefile ~/mpd.hosts -n 2 ./h6_problem1.out ./res/gr17_d.txt
pn2
pn1
Filename is ./res/gr17_d.txt
The min length of cycle is 2085
The cycle with min length is:
13 -> 14 -> 2 -> 10 -> 9 -> 1 -> 4 -> 8 -> 11 -> 15 -> 0 -> 3 -> 12 -> 6 -> 7 -> 5 -> 16 -> 13
```

較大的可能需要在收斂之後，讓螞蟻再跑很長一段時間……，看能不能剛好跑到最佳解。

```
Filename is ./res/dantzig42_d.txt
The min length of cycle is 747
The cycle with min length is:
25 -> 26 -> 23 -> 24 -> 9 -> 10 -> 11 -> 12 -> 16 -> 15 -> 14 -> 13 -> 17 -> 18 -> 19 -> 20 ->
 21 -> 22 -> 27 -> 28 -> 29 -> 30 -> 31 -> 32 -> 33 -> 34 -> 35 -> 36 -> 37 -> 38 -> 39 -> 40
-> 0 -> 41 -> 1 -> 3 -> 2 -> 7 -> 8 -> 6 -> 5 -> 4 -> 25
```

```
Filename is ./res/att48_d.txt
The min length of cycle is 35890
The cycle with min length is:
13 -> 24 -> 12 -> 20 -> 46 -> 10 -> 39 -> 8 -> 0 -> 7 -> 37 -> 30 -> 43 -> 17 -> 6 -> 27 -> 5
 -> 36 -> 18 -> 26 -> 42 -> 16 -> 29 -> 35 -> 45 -> 32 -> 19 -> 11 -> 14 -> 2 -> 21 -> 15 -> 40
  -> 33 -> 28 -> 1 -> 25 -> 3 -> 34 -> 44 -> 23 -> 9 -> 41 -> 4 -> 47 -> 38 -> 31 -> 22 -> 13
```

Any difficulties?

1. 共享費洛蒙時， barrier 記得設好。
2. 一直找不到全域最小值……。