

Архитектура вычислительных систем
Отчёт по заданию «Разработка многопоточных приложений с
использованием OpenMP»
Вариант 24

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1 Описание задачи

Задача о Пути Кулака. На седых склонах Гималаев стоят два древних буддистских монастыря: Гуань-Инь и Гуань-Янь. Каждый год в день сошествия на землю боддисатвы Араватти монахи обоих монастырей собираются на совместное празднество и показывают свое совершенствование на Пути Кулака. Всех соревнующихся монахов разбивают на пары, победители пар бьются затем между собой и так далее, до финального поединка. Монастырь, монах которого победил в финальном бою, забирает себе на хранение статую боддисатвы. Реализовать многопоточное приложение, определяющего победителя. В качестве входных данных используется массив, в котором хранится количество энергии Ци каждого монаха. При решении использовать принцип дихотомии.

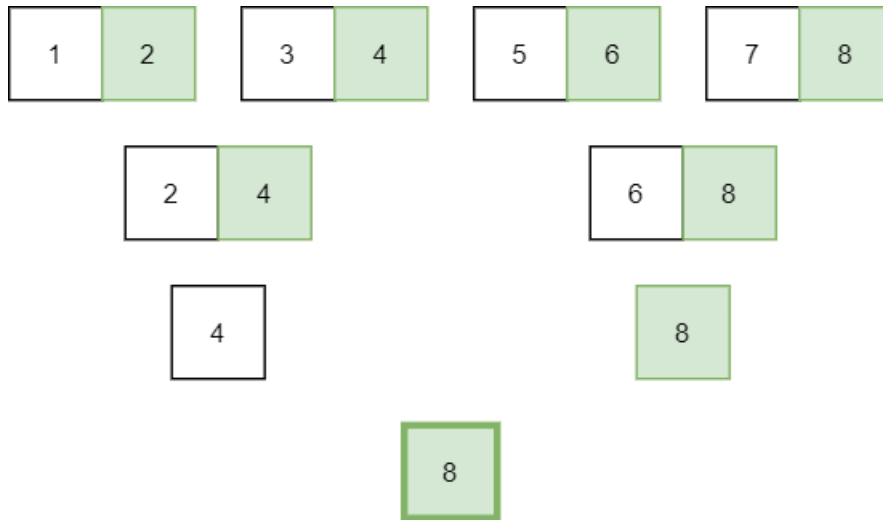
2 Реализация

На вход программе подается *size* - количество монахов в одном монастыре. Количество монахов во обоих монастырях совпадает. Затем создается массив размера $2 * size$, где каждый четный элемент - монах из монастыря Гуань-Инь, а каждый нечетный - монах из монастыря Гуань-Янь. Далее задача сводится к поиску в данном одномерном массиве монаха с наибольшим запасом энергии с помощью алгоритма, основанного на подходе «разделяй-и-властвуй». Код данного алгоритма на языке C++:

```
Monk find_max(Monk *array, int size) {
    Monk m1, m2, res;
    if (size == 1) return array[0];
    int mid = size % 2 == 0 ? size / 2 : size / 2 + 1;
    #pragma omp task shared(m1)
    m1 = find_max(array, mid);
    #pragma omp task shared(m2)
    m2 = find_max(array + mid, mid);
    #pragma omp taskwait
    return m1.energy >= m2.energy ? m1 : m2;
}
```

Таким образом, сначала будет найден монах с наибольшим количеством энергии в каждой паре - то есть все четные элементы будут сравнены по количеству энергии со своими нечетными соседями, затем монах с наибольшим количеством энергии среди найденных пар и так далее, пока не останется один монах - монастырь которого забирает себе на хранение статую боддисатвы.

Пример работы алгоритма изображен на рисунке (здесь 1, 3, 5, 7 - монахи из монастыря Гуань-Инь с соответствующими запасами энергии, а 2, 4, 6, 8 - монахи из монастыря Гуань-Янь):



Для обеспечения многопоточности используется модель «Рекурсивный параллелизм» и директивы *OpenMP*. Исходный массив разбивается на несколько подмассивов, количество которых зависит от результата функции `omp_get_max_threads()`. Затем для каждого подмассива находится свой максимальный элемент, после чего в родительском потоке находится максимальный элемент среди максимальных элементов подмассивов.

3 Формат входных данных

Входные данные задаются с помощью аргументов командной строки в следующем формате:

\$ <путь до исполняемого файла> <количество монахов в монастыре>

4 Работа программы

4.1 Пример 1

Результат работы программы со следующими входными данными:

- количество монахов в монастыре = 4

```
[Thread 0] Monk (49) from Guan-Yin is fighting against Monk (58) from Guan-Yang. The winner is Monk (58) from Guan-Yang.
[Thread 0] Monk (54) from Guan-Yin is fighting against Monk (61) from Guan-Yang. The winner is Monk (61) from Guan-Yang.
[Thread 0] Monk (58) from Guan-Yang is fighting against Monk (61) from Guan-Yang. The winner is Monk (61) from Guan-Yang.
[Thread 0] Monk (77) from Guan-Yin is fighting against Monk (89) from Guan-Yang. The winner is Monk (89) from Guan-Yang.
[Thread 0] Monk (37) from Guan-Yin is fighting against Monk (64) from Guan-Yang. The winner is Monk (64) from Guan-Yang.
[Thread 0] Monk (89) from Guan-Yang is fighting against Monk (64) from Guan-Yang. The winner is Monk (89) from Guan-Yang.
[Thread 0] Monk (61) from Guan-Yang is fighting against Monk (89) from Guan-Yang. The winner is Monk (89) from Guan-Yang.
Guan-Yang has won the battle!
```

4.2 Пример 2

Результат работы программы со следующими входными данными:

- количество монахов в монастыре = 8

```
[Thread 5] Monk (89) from Guan-Yin is fighting against Monk (43) from Guan-Yang. The winner is Monk (89) from Guan-Yin.
[Thread 7] Monk (61) from Guan-Yin is fighting against Monk (2) from Guan-Yang. The winner is Monk (61) from Guan-Yin.
[Thread 4] Monk (74) from Guan-Yin is fighting against Monk (68) from Guan-Yang. The winner is Monk (74) from Guan-Yin.
[Thread 0] Monk (5) from Guan-Yin is fighting against Monk (17) from Guan-Yang. The winner is Monk (17) from Guan-Yang.
[Thread 2] Monk (79) from Guan-Yin is fighting against Monk (86) from Guan-Yang. The winner is Monk (86) from Guan-Yang.
[Thread 3] Monk (74) from Guan-Yin is fighting against Monk (50) from Guan-Yang. The winner is Monk (74) from Guan-Yin.
[Thread 3] Monk (45) from Guan-Yin is fighting against Monk (7) from Guan-Yang. The winner is Monk (45) from Guan-Yin.
[Thread 2] Monk (28) from Guan-Yin is fighting against Monk (29) from Guan-Yang. The winner is Monk (29) from Guan-Yang.
[Thread 0] Monk (89) from Guan-Yin is fighting against Monk (61) from Guan-Yin. The winner is Monk (89) from Guan-Yin.
[Thread 0] Monk (74) from Guan-Yin is fighting against Monk (17) from Guan-Yang. The winner is Monk (74) from Guan-Yin.
[Thread 0] Monk (89) from Guan-Yin is fighting against Monk (74) from Guan-Yin. The winner is Monk (89) from Guan-Yin.
[Thread 0] Monk (86) from Guan-Yang is fighting against Monk (74) from Guan-Yin. The winner is Monk (86) from Guan-Yang.
[Thread 0] Monk (45) from Guan-Yin is fighting against Monk (29) from Guan-Yang. The winner is Monk (45) from Guan-Yin.
[Thread 0] Monk (86) from Guan-Yang is fighting against Monk (45) from Guan-Yin. The winner is Monk (86) from Guan-Yang.
[Thread 0] Monk (89) from Guan-Yin is fighting against Monk (86) from Guan-Yang. The winner is Monk (89) from Guan-Yin.
Guan-Yin has won the battle!
```

4.3 Пример 3

Результат работы программы со следующими входными данными:

- количество монахов в монастыре = 16

```
[Thread 2] Monk (96) from Guan-Yin is fighting against Monk (99) from Guan-Yang. The winner is Monk (99) from Guan-Yang.
[Thread 3] Monk (35) from Guan-Yin is fighting against Monk (92) from Guan-Yang. The winner is Monk (92) from Guan-Yang.
[Thread 0] Monk (92) from Guan-Yang is fighting against Monk (99) from Guan-Yang. The winner is Monk (99) from Guan-Yang.
[Thread 1] Monk (52) from Guan-Yin is fighting against Monk (78) from Guan-Yang. The winner is Monk (78) from Guan-Yang.
[Thread 6] Monk (98) from Guan-Yin is fighting against Monk (34) from Guan-Yang. The winner is Monk (98) from Guan-Yin.
[Thread 7] Monk (78) from Guan-Yang is fighting against Monk (98) from Guan-Yin. The winner is Monk (98) from Guan-Yin.
[Thread 7] Monk (51) from Guan-Yin is fighting against Monk (3) from Guan-Yang. The winner is Monk (51) from Guan-Yin.
[Thread 4] Monk (97) from Guan-Yin is fighting against Monk (80) from Guan-Yang. The winner is Monk (97) from Guan-Yin.
[Thread 1] Monk (51) from Guan-Yin is fighting against Monk (97) from Guan-Yin. The winner is Monk (97) from Guan-Yin.
[Thread 6] Monk (63) from Guan-Yin is fighting against Monk (96) from Guan-Yang. The winner is Monk (96) from Guan-Yang.
[Thread 0] Monk (24) from Guan-Yin is fighting against Monk (12) from Guan-Yang. The winner is Monk (24) from Guan-Yin.
[Thread 7] Monk (96) from Guan-Yang is fighting against Monk (24) from Guan-Yin. The winner is Monk (96) from Guan-Yang.
[Thread 1] Monk (58) from Guan-Yin is fighting against Monk (19) from Guan-Yang. The winner is Monk (58) from Guan-Yin.
[Thread 7] Monk (43) from Guan-Yin is fighting against Monk (18) from Guan-Yang. The winner is Monk (43) from Guan-Yin.
[Thread 6] Monk (58) from Guan-Yin is fighting against Monk (43) from Guan-Yin. The winner is Monk (58) from Guan-Yin.
[Thread 1] Monk (3) from Guan-Yin is fighting against Monk (47) from Guan-Yang. The winner is Monk (47) from Guan-Yang.
[Thread 7] Monk (82) from Guan-Yin is fighting against Monk (23) from Guan-Yang. The winner is Monk (82) from Guan-Yin.
[Thread 0] Monk (47) from Guan-Yang is fighting against Monk (82) from Guan-Yin. The winner is Monk (82) from Guan-Yin.
[Thread 1] Monk (46) from Guan-Yin is fighting against Monk (98) from Guan-Yang. The winner is Monk (98) from Guan-Yang.
[Thread 0] Monk (68) from Guan-Yin is fighting against Monk (4) from Guan-Yang. The winner is Monk (68) from Guan-Yin.
[Thread 7] Monk (98) from Guan-Yang is fighting against Monk (68) from Guan-Yin. The winner is Monk (98) from Guan-Yang.
[Thread 1] Monk (45) from Guan-Yin is fighting against Monk (11) from Guan-Yang. The winner is Monk (45) from Guan-Yin.
[Thread 7] Monk (97) from Guan-Yin is fighting against Monk (80) from Guan-Yang. The winner is Monk (97) from Guan-Yin.
[Thread 6] Monk (45) from Guan-Yin is fighting against Monk (97) from Guan-Yin. The winner is Monk (97) from Guan-Yin.
[Thread 0] Monk (99) from Guan-Yang is fighting against Monk (98) from Guan-Yin. The winner is Monk (99) from Guan-Yang.
[Thread 0] Monk (97) from Guan-Yin is fighting against Monk (96) from Guan-Yang. The winner is Monk (97) from Guan-Yin.
[Thread 0] Monk (99) from Guan-Yang is fighting against Monk (97) from Guan-Yin. The winner is Monk (99) from Guan-Yang.
[Thread 0] Monk (58) from Guan-Yin is fighting against Monk (82) from Guan-Yin. The winner is Monk (82) from Guan-Yin.
[Thread 0] Monk (98) from Guan-Yang is fighting against Monk (97) from Guan-Yin. The winner is Monk (98) from Guan-Yang.
[Thread 0] Monk (82) from Guan-Yin is fighting against Monk (98) from Guan-Yang. The winner is Monk (98) from Guan-Yang.
[Thread 0] Monk (99) from Guan-Yin is fighting against Monk (98) from Guan-Yang. The winner is Monk (99) from Guan-Yang.
Guan-Yang has won the battle!
```