Heuristic-based Task-to-Thread Mapping in Multi-Core Processors

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Introduction

- Enhance the performance of real-time applications using OpenMP
- Emerge a challenge with the predictability of OpenMP applications
- Study the applicability of heuristic algorithms in mapping
- Achieve a work-conserving and load-balancing mapping
- Minimize scheduling time (end-to-end response time) and idle time

Motivations

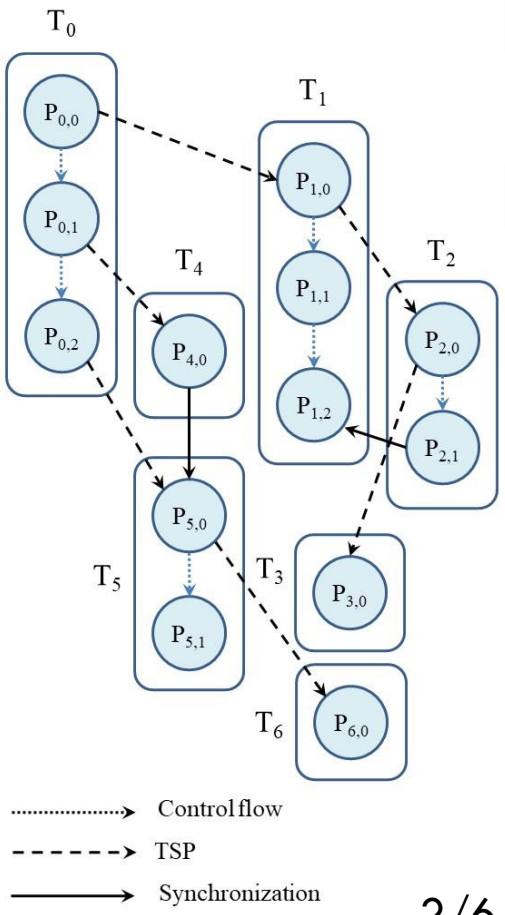
The main problems with the existing mappings:

- They do not schedule tasks on threads based on global information of the system.
- They do not use temporal conditions of the system (e.g., execution time and deadline) in each phase of the mapping process.
- Most of them do not apply various heuristic techniques.

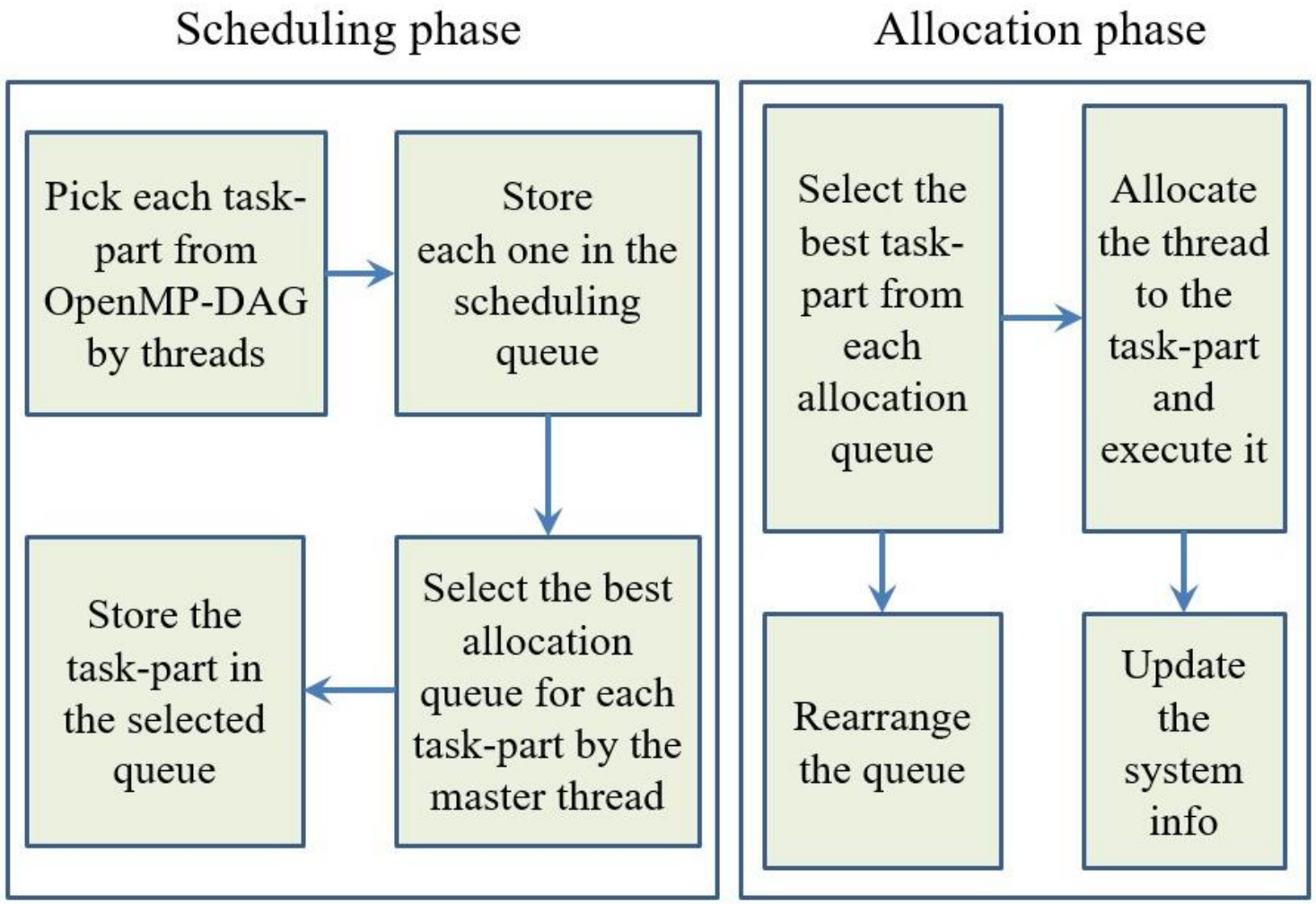
Source code

```
#pragma omp parallel num_threads(4)
#pragma omp single                          // T0
{
   code00;
   #pragma omp task                         // T1
   {
      code10;
      #pragma omp task                      // T2
      {
         code20;
         #pragma omp task                   // T3
            code30;
         code21;
      }
      code11;
      #pragma omp taskwait
      code12;
   }
   code01;
   #pragma omp task depend(out:x)           // T4
      code40;
   code02;
   #pragma omp task depend(in:x)            // T5
   {
      code50;
      #pragma omp task                      // T6
         code60;
      code51;
   }
}
```

Direct Acyclic Graph (DAG)



Proposed Mapping Algorithm



Proposed Mapping Algorithm

The suggested scheduling heuristics:

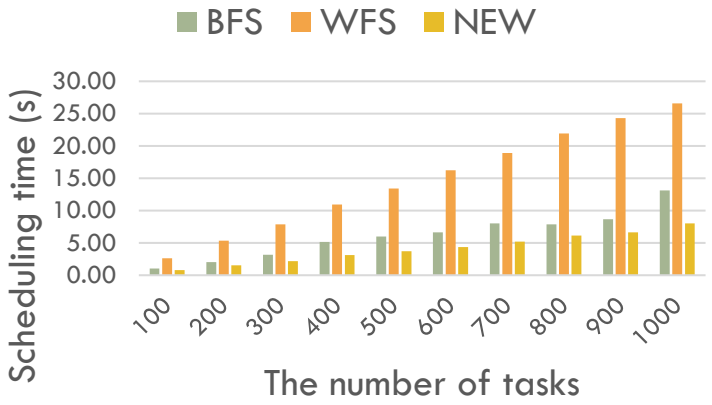
- *First-fit scheduling*: the thread (i.e., allocation queue) containing the minimum number of task-parts
- *Best-fit scheduling*: the queue with the minimum execution time
- *Optimum-fit scheduling*: the queue including the maximum response time (of the task-parts)
- *Multi-criteria scheduling*: the queue having the characteristics of the previous heuristics

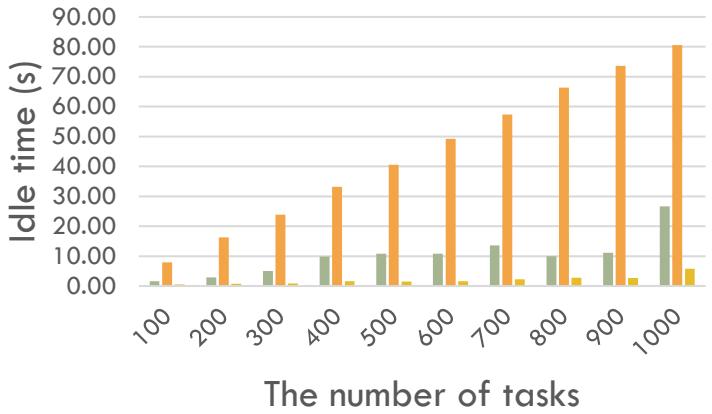
The suggested allocation heuristics:

- *Best-fit allocation*: the task-part having the minimum execution time
- *Optimum-fit allocation*: the task-part with the maximum response time
- *Multi-criteria allocation*: the task-part including the shortest execution time and the longest response time

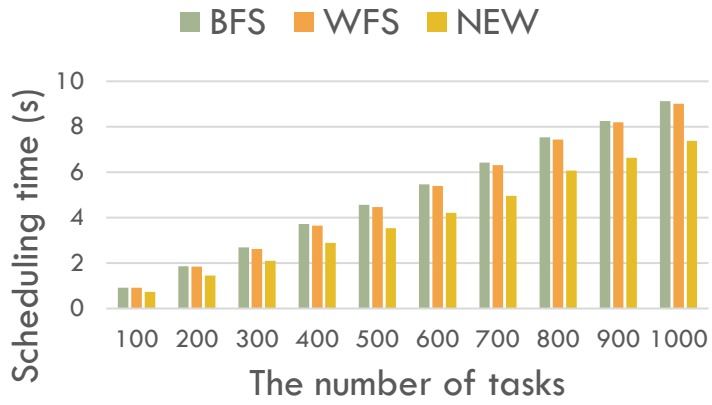
Evaluation Results

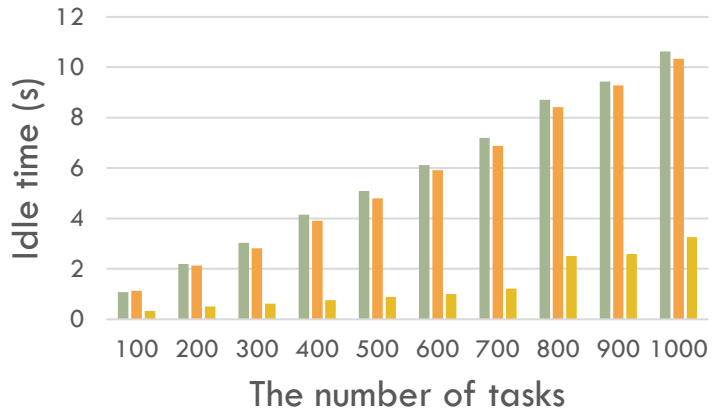
Tied tasks





Untied tasks





The proposed mapping:

- Decreases the scheduling time about 25% less than that of BFS and about 45% less than that of WFS
- Reduces the idle time about 75% less than that of BFS and about 85% less than that of WFS

The best heuristic pair: *best-fit*, *multi-criteria*

Future Works

The evaluation of the mapping under more complex system models, supporting:

- The creation of multiple child tasks by a task-part at TSP
- Different graphs (in size and proportion)
- Different numbers of threads

THANKS FOR YOUR ATTENTION!

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