Configuration of Parallel Real-Time Applications on Multi-Core Processors

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Agenda

- Introduction
- The Suggested Approach
- Measurement Process
- Heat Benchmark
- Hardware Platform
- Evaluation

Introduction

- **Goal:** Using parallel programming models to improve the performance of real-time applications in modern processors
- **Constraints:** Applying static timing analysis for simpler models or measurement-based analysis using traditional platforms (or considering only sequential algorithms)
- **Motivation:** Providing an efficient configuration for the allocation of the parallel program in the computing units of the processor

The Suggested Approach

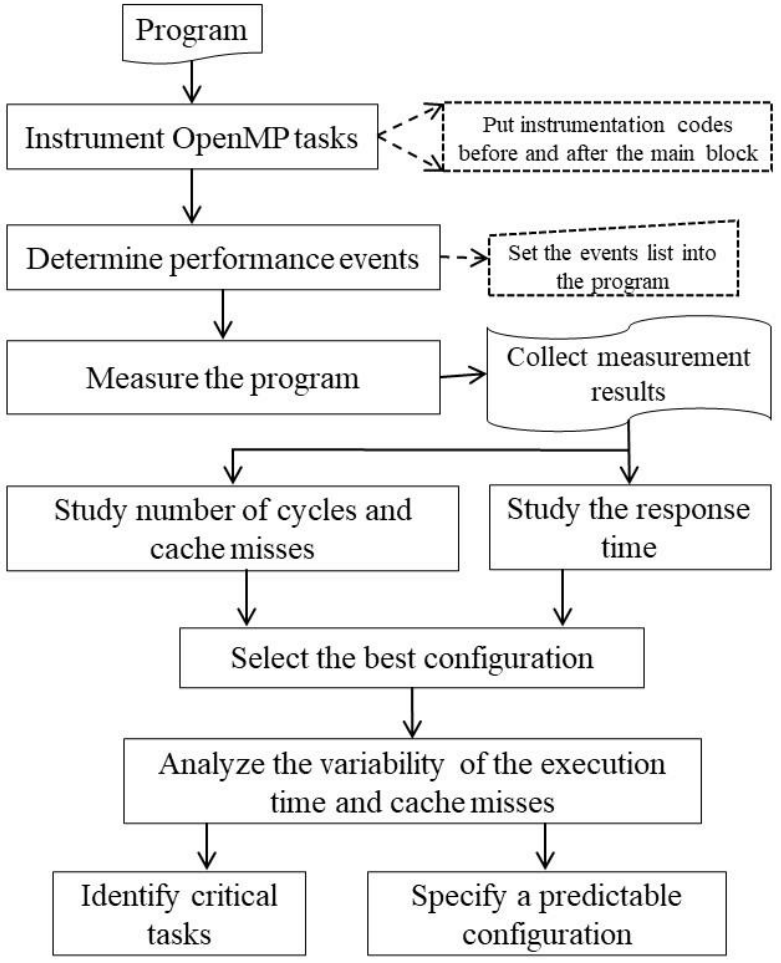
We have suggested a measurement-based approach to

- Assess the execution time of OpenMP tasks
- Analyze the importance of doing a timing analysis
- Specify proper configurations of OpenMP directives
- Identify critical tasks
- Understand the predictability of the system/application

The Suggested Approach

Goals:

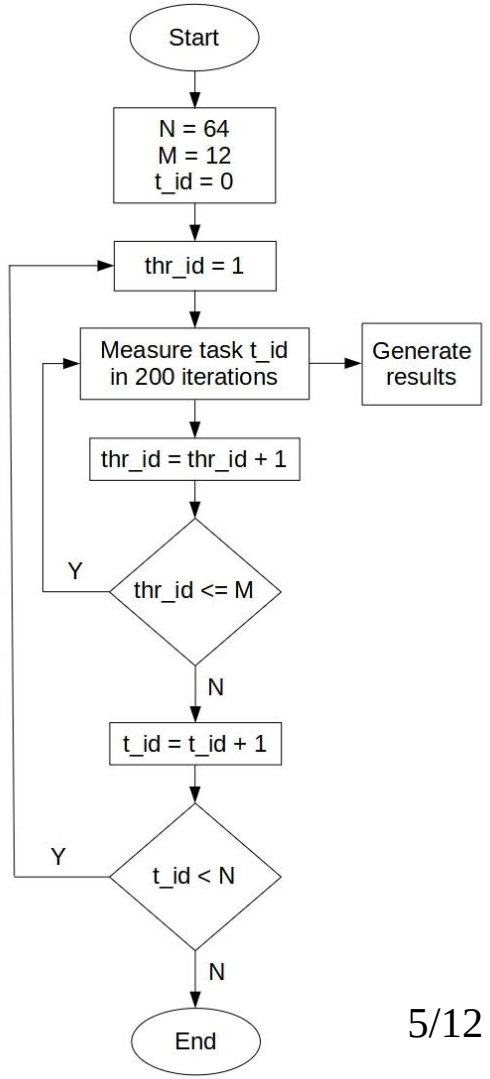
- Studying the behavior of the application using measurement results
- Selecting the best configuration for the allocation of the parallel program
- Identifying critical tasks for reducing the need to measure at runtime
- Reducing the runtime overhead



Measurement Process

Measuring the program with Linux perf under different numbers of threads

- *N*: the number of tasks
- *M*: the number of threads
- *t_id*: the identifier of the current task
- *thr_id*: the thread number



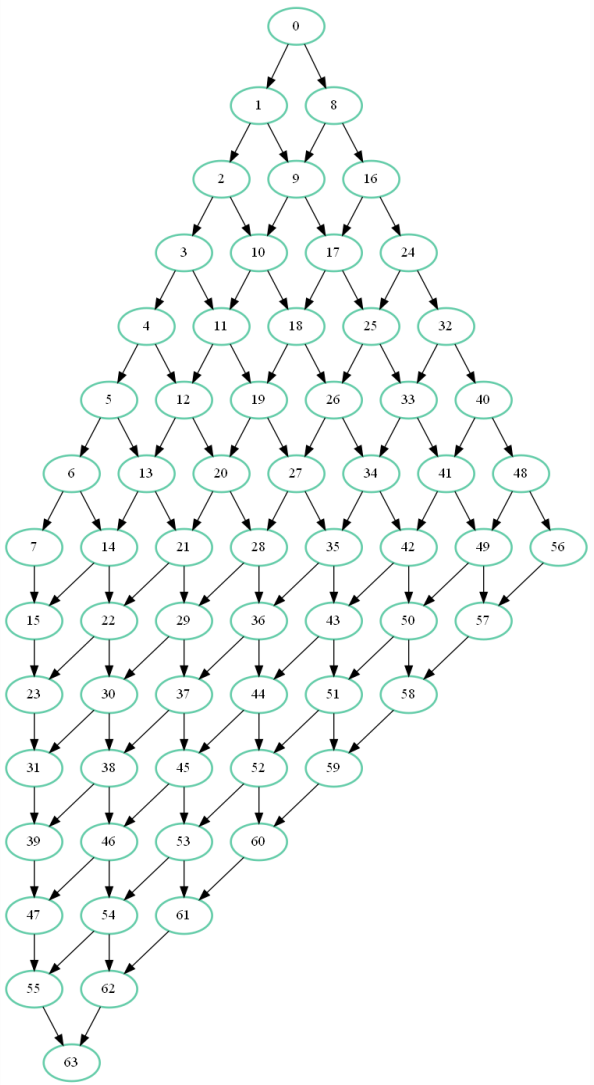
Measurement Process

```
#pragma omp task
{
        /* Start the measurement process for t_id */
        /* Get the monitor of the current thread */
        uint32_t thread_num = omp_get_thread_num();
        xavier_monitor_t monitor = monitors[thread_num];

        if ((task_no == -1) || (task_no == t_id)) {
                /* Start measuring the events */
                xavier_reset(&monitor);
                xavier_enable(&monitor);
        }

        code();

        /* Terminate the measurement process for t_id */
        if ((task_no == -1) || (task_no == t_id)) {
                /* Stop measuring the events */
                xavier_disable(&monitor);

                /* Get measurement results of the events */
                xavier_result_t results;
                xavier_read(&monitor, &results);

                Store measurement results();
        }
}
```

Heat Benchmark

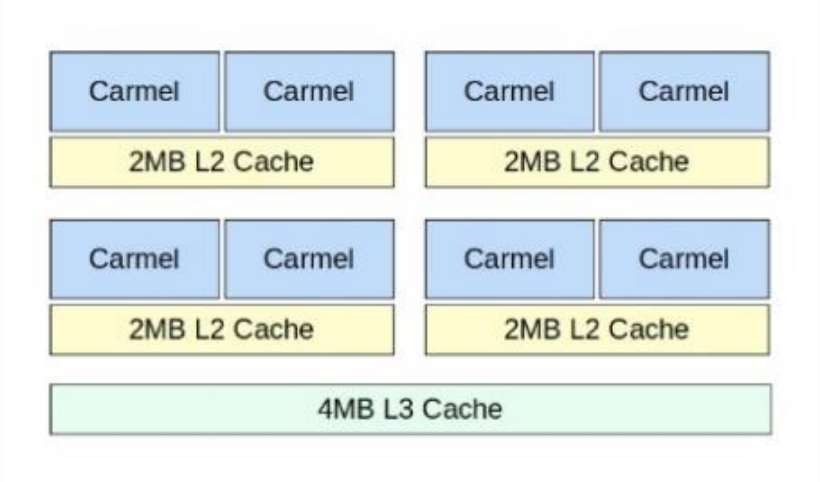
Characteristics:

- Applying an iterative Gauss-Seidel method to solve the heat equation
- Explaining the distribution of heat in a given region over time
- Including 64 tasks
- Containing a sophisticated TDG

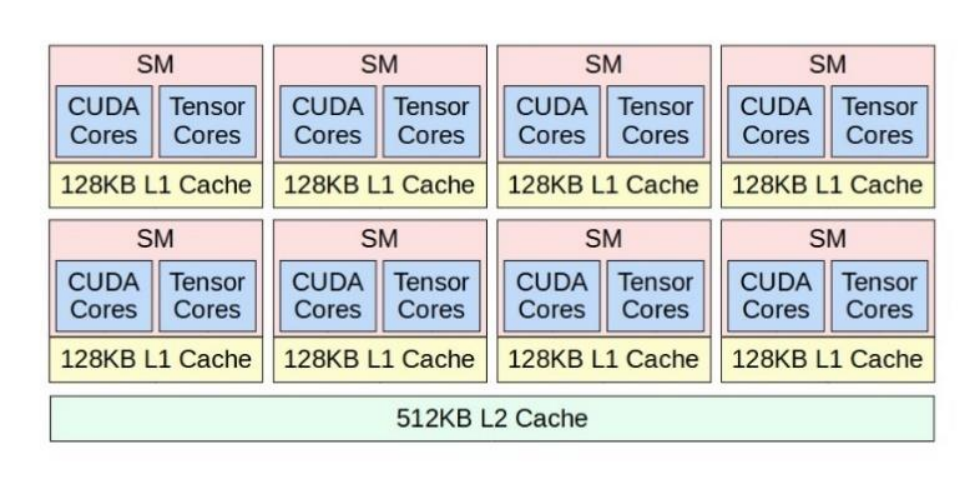


Hardware Platform

The OpenMP-based heat benchmark has been evaluated on a Jetson AGX Xavier, in terms of the number of CPU cycles and cache-level metrics.

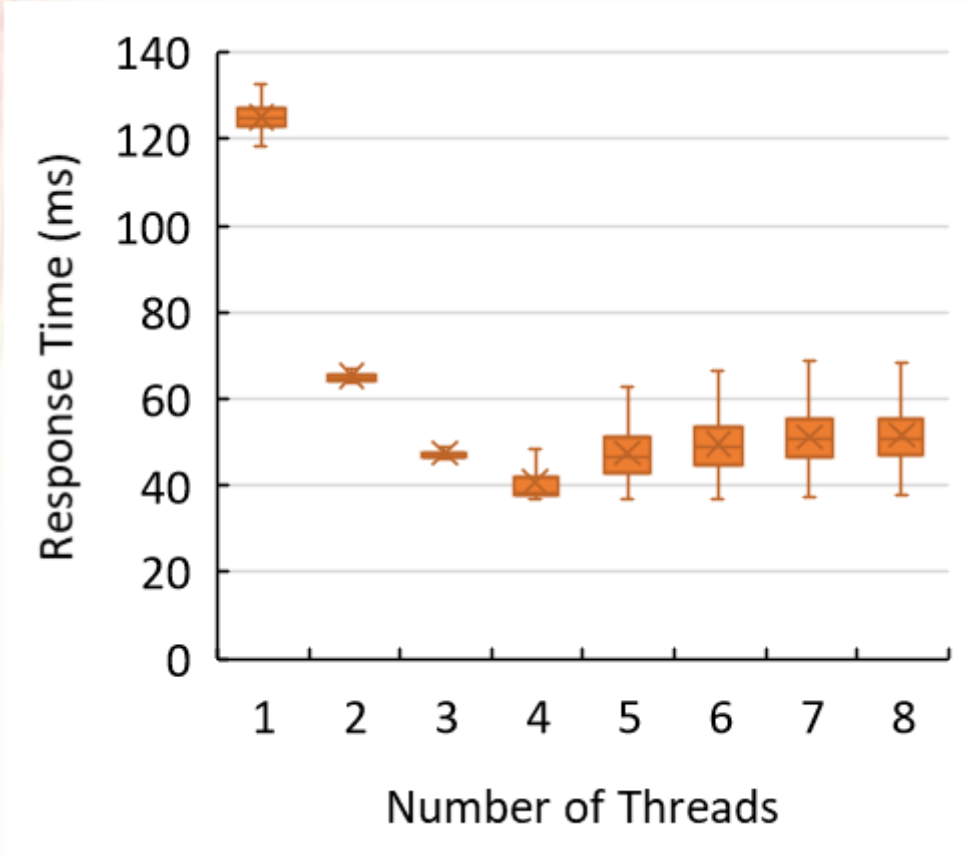


CPU COMPLEX

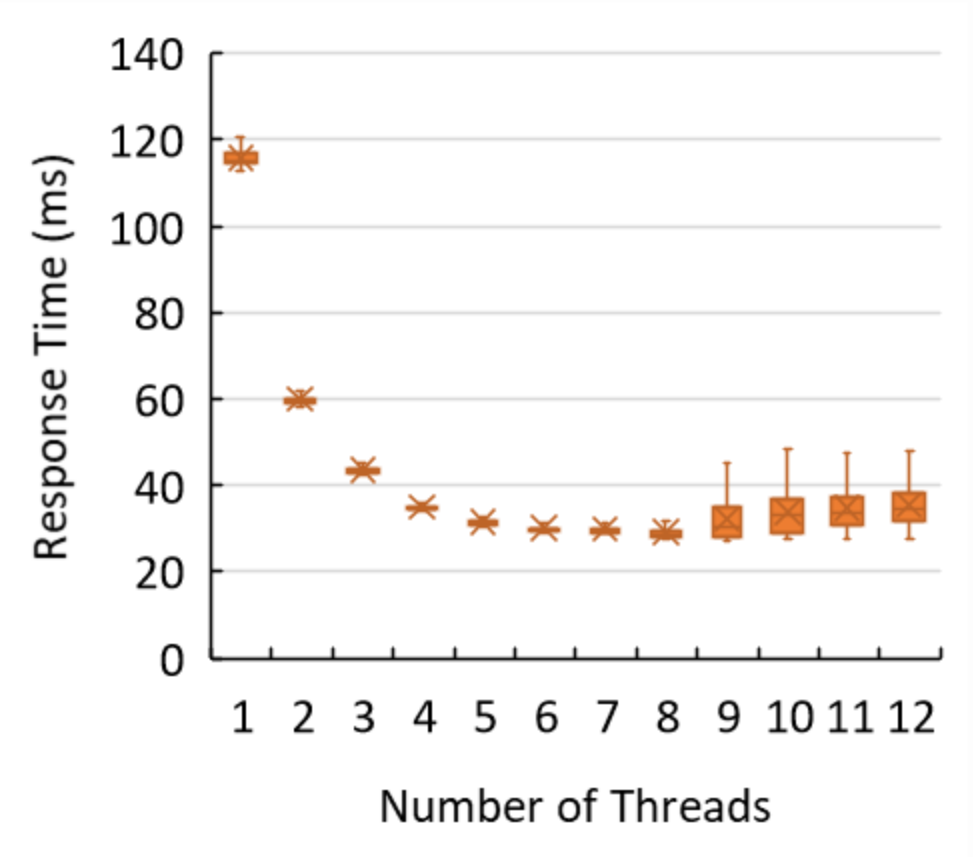


VOLTA GPU

Evaluation



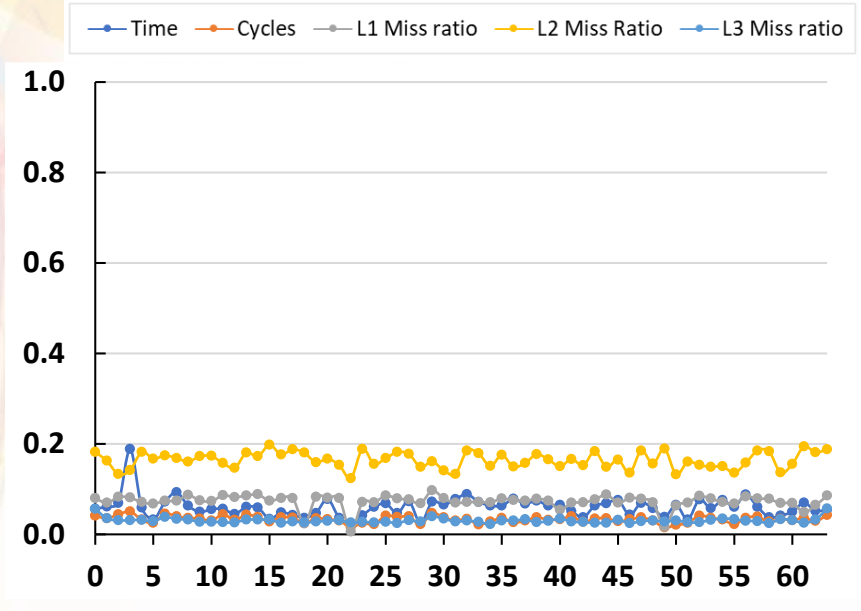
4 active cores



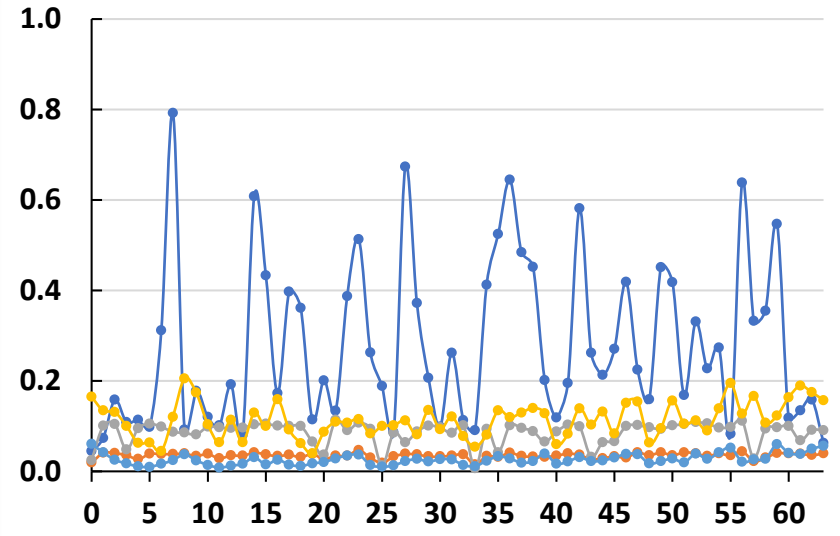
8 active cores

Evaluation

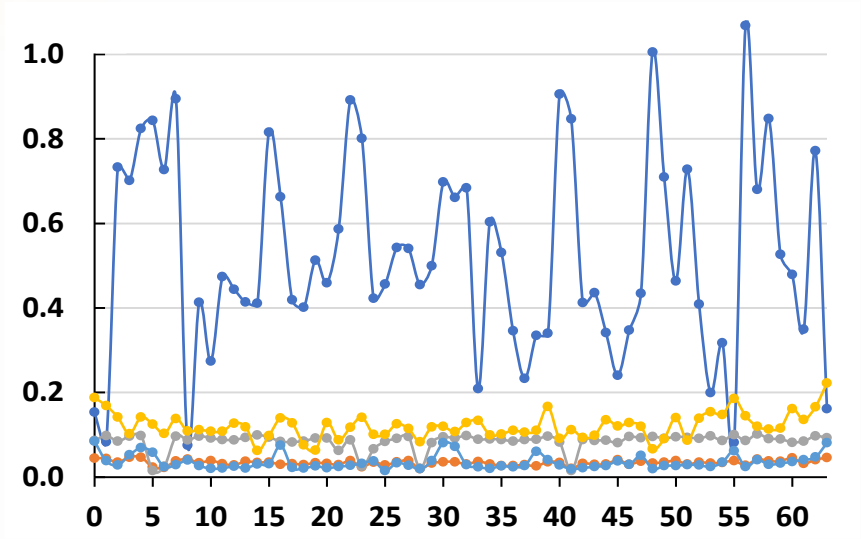
(a)



(b)



(c)



Coefficient of Variance

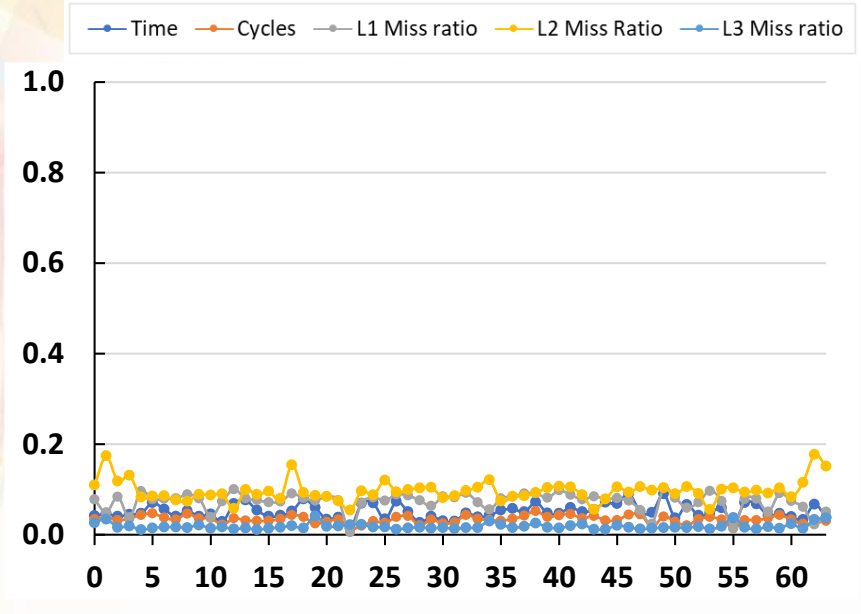
(a) 4 active cores, 2 OMP threads

(b) 4 active cores, 4 OMP threads

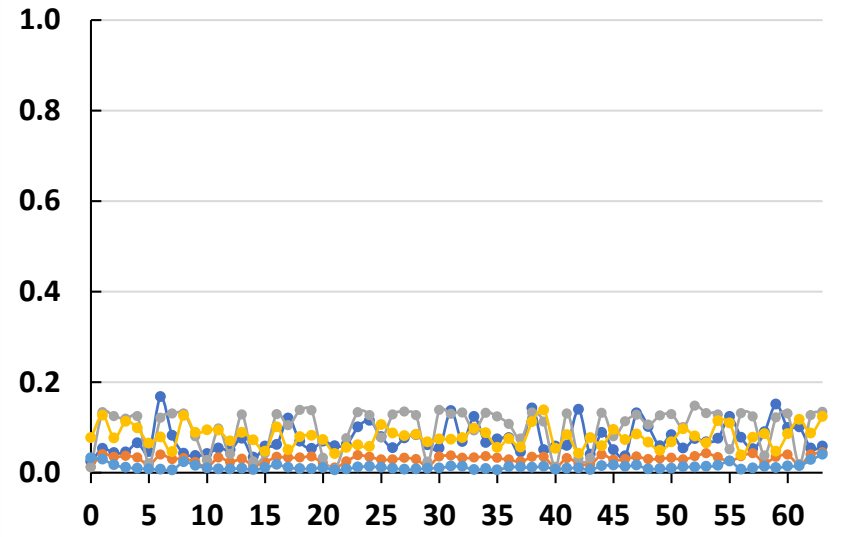
(c) 4 active cores, 8 OMP threads

Evaluation

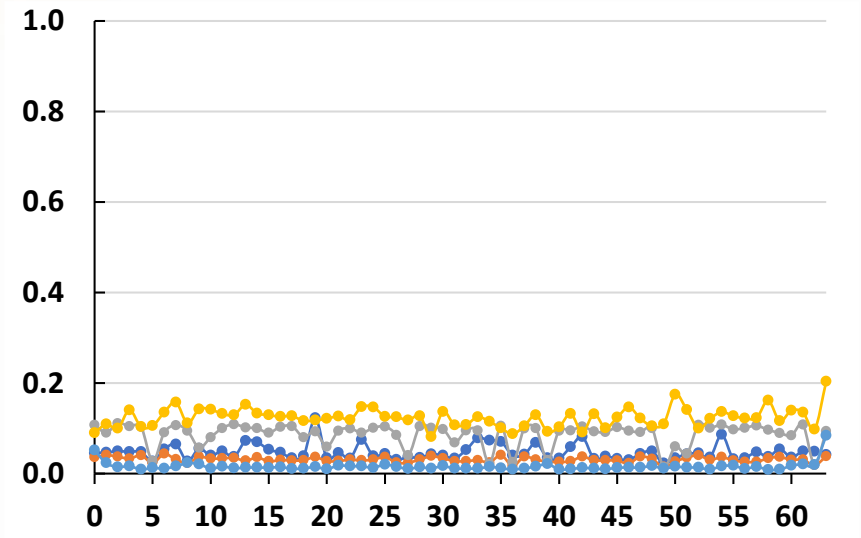
(a)



(b)



(c)



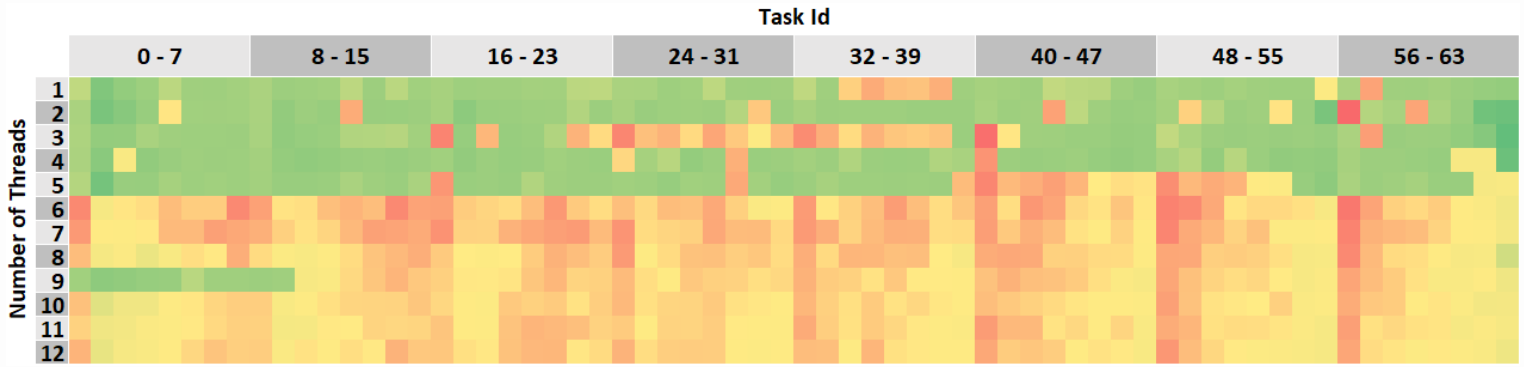
Coefficient of Variance

(a) 8 active cores, 2 OMP threads

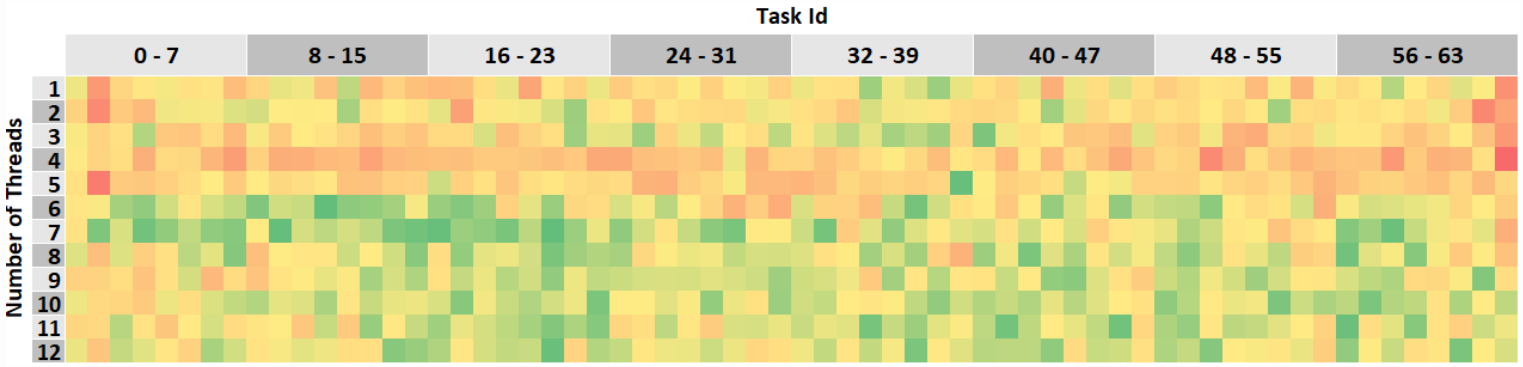
(b) 8 active cores, 4 OMP threads

(c) 8 active cores, 8 OMP threads

Evaluation



L2 miss ratio mean (min = 0.22, max = 0.43)



Coefficient of Variance for L2 miss ratio (min = 0.03, max = 0.20)

THANKS

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