An Application Parameter Search Method Based on the Binary Search Algorithm for Performance Tuning

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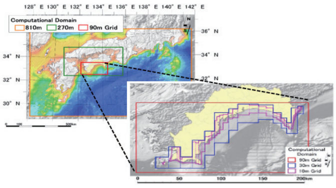
Background

Problems on parameter tuning

- Performance tuning is mandatory to fully exploit the potential of modern computing systems.
- The full search method is the reliable way for parameter tuning.
  - Lots of executions of an application are necessary in full search method
  - The time for parameter tuning becomes longer due to the long time of each execution for an application.

Need to reduce the execution time for parameter tuning

Target application: Tsunami simulation[1]



- The simulation calculates the inundation depth and the starting time of the inundation until the given simulated time.
- Numerical method: The non-linear shallow water equations
- Numerical scheme: The staggered leap-flog finite difference method
- Code Bytes/Flop = 1.85 (Memory-intensive for most of computers)
- **The execution time can be adjustable by the simulated time.**

Application parameter search method based on the binary search algorithm

Key idea

Shorten the time of each execution of an application for tuning parameters

-Use the lower resolution input data than the original one if it is available.

-Adjust the ***simulated time in parameter tuning*** (***STPT***) appropriately.

- To minimize the execution time, the ***STPT*** should be as small as possible.
- Extremely minimized ***STPT*** changes the behavior of an application.

It is necessary to find the appropriate *STPT* for fast parameter tuning

A search method for *STPT* using the binary search algorithm

Step1. Search the appropriate ***STPT*** by the binary search algorithm.

1.1 The ***STPT*** is set to the half of the previous ***STPT***.

1.2 Measure the execution time with the ***STPT*** set in 1.1.

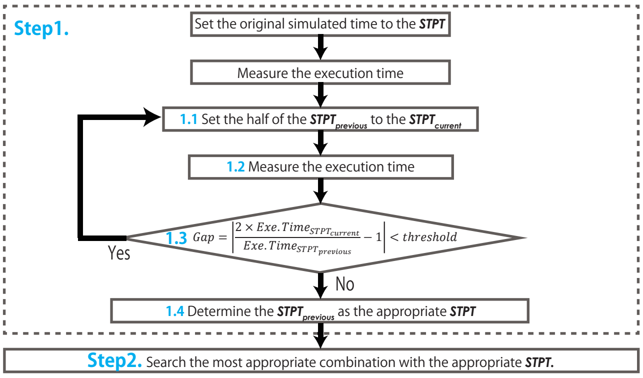
1.3 If the following condition is satisfied, the behavior of an application is considered unchanged. Go to 1.1 again.

Condition : The execution time is proportional to the simulated time.

Otherwise, go to 1.4.

1.4 Determine the previous ***STPT*** as the appropriate ***STPT***.

Step2. Perform parameter tuning by the brute-force searching method using the appropriate ***STPT*** obtained in Step1.



Step1.

Set the original simulated time to the ***STPT***

Measure the execution time

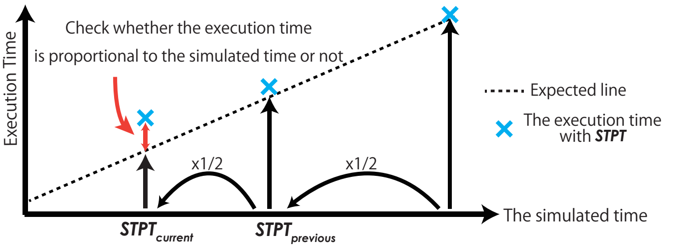
1.1 Set the half of the $STPT_{previous}$ to the $STPT_{current}$

1.2 Measure the execution time

1.3 $Gap = \left|\frac{2 \times Exe.Time_{STPT_{current}}}{Exe.Time_{STPT_{previous}}} - 1\right| < threshold$

1.4 Determine the $STPT_{previous}$ as the appropriate ***STPT***

Step2. Search the most appropriate combination with the appropriate ***STPT.***


Execution Time
Check whether the execution time
is proportional to the simulated time or not
x1/2
x1/2
Expected line
The execution time with STPT
The simulated time
STPT current
STPT previous

Case study : Evaluation using KNL

Experimental setup

Tsunami simulation

- The original simulated time is 3600
- The original resolution input data is about 15 GB
- The lower resolution input data is about 2 GB

Evaluated computing system

- Intel Xeon Phi 7290B (Knights Landing)
- Candidates of system parameters is selected by [2]

Candidates of System Parameters

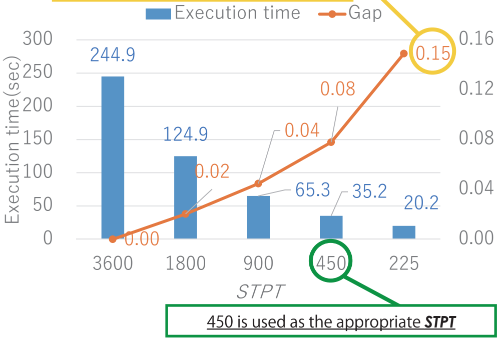
Cluster Mode	Memory Mode	Thread Affinity	Number of Threads
Quadrant	FlatMCDRAM	Scatter, Balanced	72, 144

Settings for searching the appropriate *STPT*

- Threshold for the condition : 0.1
  - This threshold is selected empirically

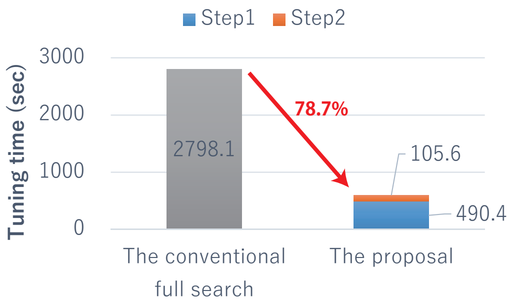
Determine the appropriate *STPT*

When the ***STPT*** is 225, the condition is not satisfied.



450 is used as the appropriate ***STPT***

Comparison of parameter tuning time



By the appropriate ***STPT*** searched by the proposed method, the time for each execution of an application for parameter tuning is shortened so that the overall tuning time can be reduced.

The parameter combination found by tuning with the proposed method is same as that by the conventional full search method.

Conclusions and future work

- To reduce the time for parameter tuning, we propose the method of searching the appropriate simulated time for parameter tuning using the binary search algorithm.
- The proposed method can reduce the parameter tuning time to 78.7% compared with the conventional full search method.
- In the future, the proposed method is evaluated by using other applications and computing systems.

References

[1]A. Musa, O. Watanabe, H. Natsuoka, H. Hokari, T. Inoue, Y. Murashima, Y. Ohta, R. Hino, S. Koshimura, H. Kobayashi, “Real-time tsunami inundation forecast system for tsunami disaster prevention and mitigation” , The Journal of Supercomputing, (online), DOI: 10.1007/s11227-018-2363-0 (2018).

[2]K. Komatsu, T. Kishitani, M. Sato, A. Musa and H. Kobayashi, "Search Space Reduction for Parameter Tuning of a Tsunami Simulation on the Intel Knights Landing Processor," 2018 IEEE 12th International Symposium on Embedded Multicore/Many-core Systems-on-Chip (MCSoC), Hanoi, 2018, pp. 117-124.