Automatic Profiling for Climate Modeling

Anja Gerbes, Nabeel Jamah, Julian Kunkel

1Center for Scientific Computing (CSC) 2Universität Hamburg 3Deutsches Klimarechenzentrum (DKRZ)

ABSTRACT

Some applications are time consuming like climate modeling, which include lengthy simulations. Hence, coding is sensitive for performance. Spending more time on optimization of specific code parts can improve total performance. Profiling an application is a well-known technique to do that. Many tools are available for developers to get performance information about their code. With our provided python package Performance Analysis and Source-Code Instrumentation Toolset (PASICT), a automatic instrumentation of an user’s source code possible. Developers mark the parts that they need performance information about. We present an effort to profile climate modeling codes with two alternative methods.

- usage of GGDML translation tool to mark directly the computational kernels of an application for profiling.
- usage of GGDML translation tool to generate a serial code in a first step and then use LLVM/Clang to instrument some code parts with a profiler’s directives.

The resulting codes are profiled with the LIKWID profiler. Alternatively, we use perf and OProfile’s output to measure hardware characteristics. The performance report with a visualization of the measured hardware performance counters in generating Radar Charts, Lates Tables, Box Plots are interesting for scientist to understand the bottlenecks of their codes.

INTRODUCTION

- Code profiling helps in identifying algorithmic bottlenecks, so called hot spots.
- Hot spots are code regions which take the most execution time, the most common source are loops.
- An example of such time consuming loops are computational kernels in climate modeling.
- These stencil computational kernels are in general memory-bound.
- Identifying which parts of the code are responsible for the critical hot spots is important, making a hot spot faster can have a big pay-off.
- In a previous work we selected some operators to optimize compile time and performance, we presented an effort in which we explored the compilation process.
- Different combinations of optimization flags of a compiler including processor-specific flags are provided.
- Provided optimized compilation time and maintained the application performance.
- Automatic detection of compiler flags for performance optimization.
- In the current work, we prepare the subject application for profiling with LIKWID.
- Automatic instrumentation and profiling of scientific code.
- Two different methods are used to prepare the code for profiling.
- A comparison of the profiling results with the two methods is made.

METHODOLOGY

- A simple test climate model application is written in C language with GGDML extensions.
- GGDML source-to-source translation tool transforms the code into two different code versions:
  - A code that is prepared with OpenMP pragmas & LIKWID markers, which is ready to be profiled.
  - A serial code without profiling markers & multithreading pragmas, which has to be marked with LLVM/Clang.
- The resulting two code versions are profiled with LIKWID, and the results are compared.

GGDML TRANSLATION

- General Grid Definition & Manipulation Language (GGDML) source-to-source translation tool of AIMES Project is a higher-level set of language extensions to support earth system modeling.
- It allows to develop models from the scientific perspective, not machines perspective.
- Applications developed with GGDML need to be translated with a special translation tool.

CLANG TOOLING

- The interesting thing in using Clang is to modify the Abstract Syntax Tree (AST) on-the-fly to use the toolset for performance analysis and source-code instrumentation.
- The structure of the AST is representing the logical structure of a source code, because an AST contains the stored position information of every element in this code.
- By reimplementing the RecursiveASTVisitor template class, we can specify which AST nodes we are interested by overriding relevant methods.
- The visitor design pattern can be used to reach every node of the tree and perform some action when the process comes to a given type of nodes.

TEST APPLICATION

- An Atmospheric/Climate modeling code.
  - It runs iteratively in multiple time-steps.
  - It executes different model components.
  - Components execute a variety of kernels.
  - Kernels apply stencils operators to compute a variables’ values over the grid.
- Those kernels are compute intensive codes.
- The application’s performance is determined by the performance of those kernels.
- Kernels exploit parallel execution capabilities of the processors using OpenMP.

CONCLUSION

- Both tools were successful in marking the code for profiling.
- GGDML source-to-source translation tool based on higher semantics of the language extensions.
- Clang source-to-source instrumentation tool based on the clang node type.
- The two methods could be used for collecting profiling information.

ACKNOWLEDGMENTS

This work was supported in part by the German Research Foundation (DFG) through the Priority Programme 1648 “Software for Exascale Computing” (SPEXEX) (GZ LU 1553/11-1).

FUTURE WORK

- Automatic identification of bottlenecks
- Identification of HPC code patterns suitable for optimization
- Optimization of LLVM translation for HPC relevant patterns
- Compiler-level optimization of typical HPC code structures
- PASICT’s functionality as a black box for other scientific application domains
- Extension of python package PASICT
- Support more types of AST nodes