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Roofline-Model-Driven Optimizations for Elastic Wave Propagation on Modern Processors

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Abstract

Modern computing chips are tagged with a maximum performance, defined as the maximum attainable floating point operations per second (FLOPS) which, however, cannot be effectively attained by most software applications. Very frequently wave simulation applications can only reach a small percentage of the peak performance of such computers in their most naive versions. Hence code optimization, i.e. being able to improve the percentage of usage of the hardware, leads to great returns in terms of time-to-solution and energy usage. Nevertheless code optimization is a non-trivial task which can appear endless unless some thorough study of the code algorithmics and the computer architecture are carried out.

Full wave elastic propagation is expensive both, computational- and development-wise. Hence, maximizing the efficiency of propagation codes at the minimum development cost is important. To that goal, a mechanism that evaluates both the current and attainable maximum efficiency of your application is needed. Within this work we will show our experience in enhancing an elastic wave propagation code by means of a roofline-directed optimization strategy. This strategy guides developers in finding potentially beneficial optimizations and assessing when the maximum possible performance has been achieved.

The roofline model provides with insight into an application's behavior by placing its performance into a graphical representation bounded by both the maximum (attainable) FLOPS and memory bandwidth. In order to use the model, a measure of the application's operational intensity and efficiency is needed. The model identifies the upper limit of the application's performance at its current operational intensity, thus suggesting a set of profitable optimizations and their implementation order. This, in turn, helps reducing code development costs while attaining the best performance enhancement possible for the target application.

In this work we apply the roofline model to an elastic wave propagation application. We show the process that we have followed to optimize a production-ready code, almost doubling its performance in a few series of steps by means of reducing performance gaps in the roofline model in a sequential way.