

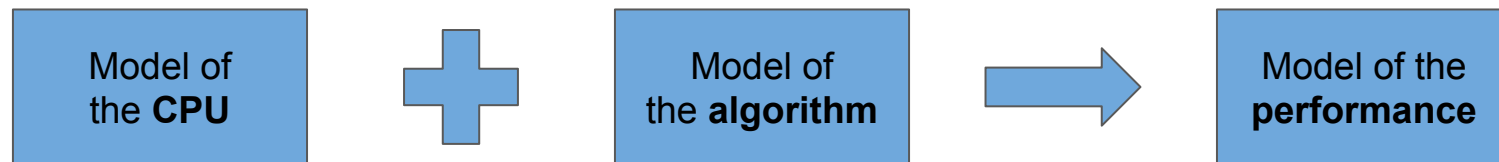
Short Introduction to the Roofline Model

Xavier Besseron

University of Luxembourg, RUES
Luxembourg XDEM Research Centre
<http://luxdem.uni.lu/>

UL HPC School
June 2019

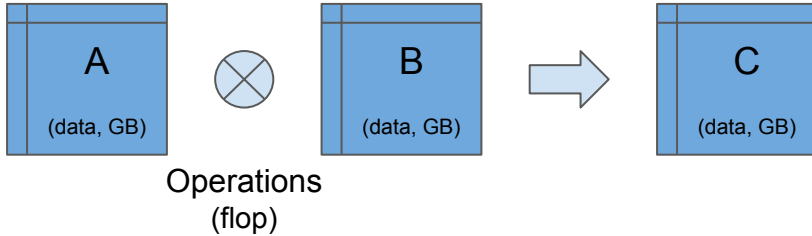
Roofline model Overview



- Estimate the **performance** of an **algorithm** on a given **CPU**
 - Also applies to GPUs, TPUs, etc.
- **Throughput** oriented model
- Identify the bottleneck
- Allow to improve the implementation of an algorithm

Roofline model

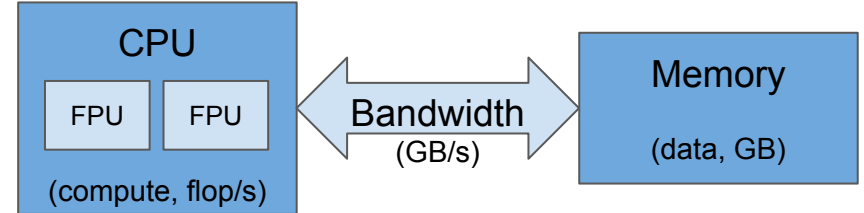
Model of an algorithm



Algorithm characteristics

- Operations: Gflop
 - Data: GB
- Arithmetic Intensity**
AI: flop / Byte

Model of a CPU



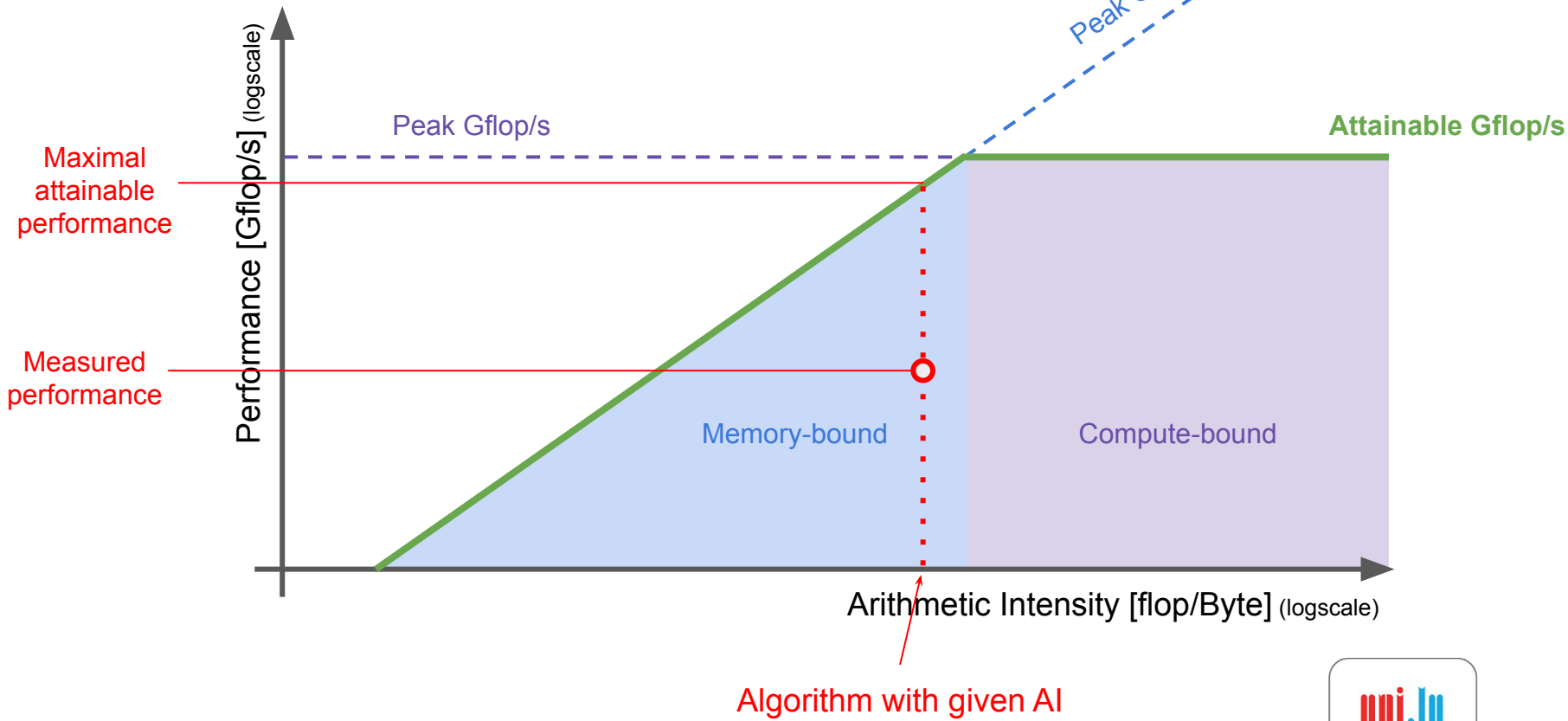
Peak performance limited by

- Compute operations: Gflop/s
- Data bandwidth: GB/s

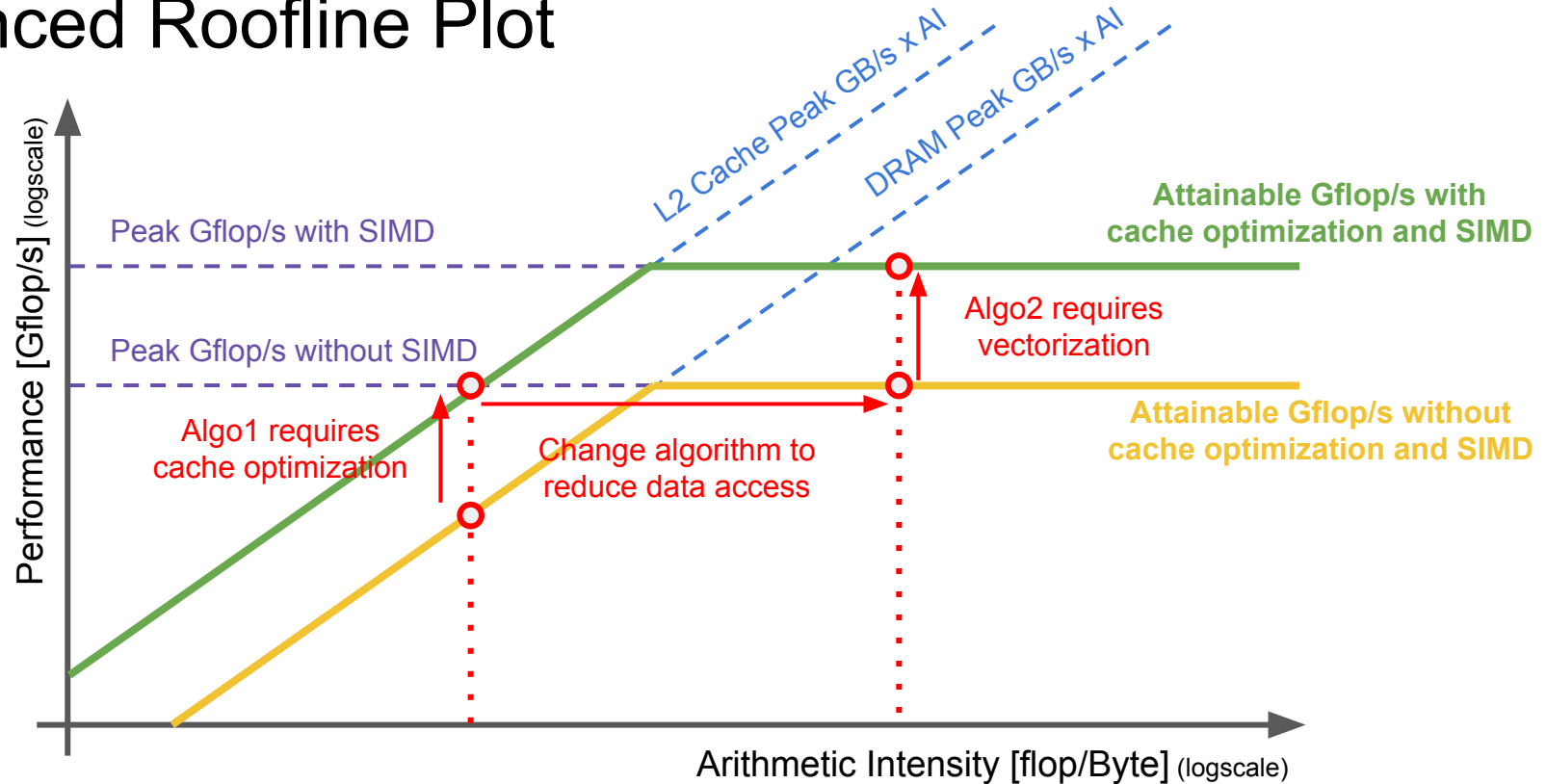
Attainable performance

$$\text{Gflop/s} = \min \left\{ \begin{array}{l} \text{Peak Gflop/s} \\ \text{AI} \times \text{Peak GB/s} \end{array} \right.$$

Roofline Plot



Advanced Roofline Plot



SIMD = Single Instruction, Multiple Data, ie vectorized instructions



Comments about the Roofline Model

In theory

- Gives good insight of the bottleneck of a given algorithm

In practice, use automatic tools

- CPU model can be hard to find
- Algorithm characterization is hard for complex algorithm

Warning

- The Roofline Model tells if an algorithm performs well,
- not if the algorithm is the best for your problem
- e.g. Bubble sort $O(n^2)$ vs Quicksort $O(n \log n)$

Tools to work with the roofline

CS Roofline Toolkit, Berkeley Lab

<https://bitbucket.org/berkeleylab/cs-roofline-toolkit/>

LIKWID, RRZE-HPC

<https://github.com/RRZE-HPC/likwid>

Intel Advisor, Intel

<https://software.intel.com/en-us/advisor>

More details

Roofline: An Insightful Visual Performance Model for Multicore Architectures, Williams et al., CACM, 2009

<https://people.eecs.berkeley.edu/~kubitron/cs252/handouts/papers/RooflineVyNoYellow.pdf>

Performance Tuning of Scientific Codes with the Roofline Model, Williams et al., SC'18 Tutorial, 2018

<https://crd.lbl.gov/assets/Uploads/SC18-Roofline-1-intro.pdf>

Applying the roofline model, Ofenbeck et al., ISPASS, 2014

http://spiral.ece.cmu.edu:8080/pub-spiral/pubfile/ispass-2013_177.pdf

Practical session with Intel Advisor on Iris

Follow the instructions at https://gitlab.uni.lu/xbesson/tutorial_roofline_model

