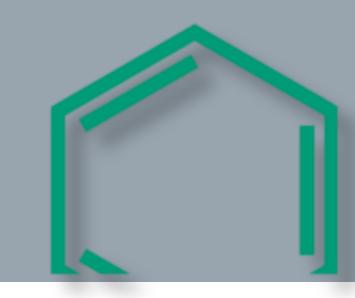


Node-Level Performance Engineering

Introduction



Dimensional gymnastics

- I cycle = smallest unit of time on a CPU ("heartbeat")
 - Clock speed of typical CPU: 2.4 Gcy/s (or GHz)
- Basic unit of work: Floating-point operation (Flop)
 - Typical peak performance of 20-core CPU: P_{peak} = 1536 Gflop/s = 1.536 Tflop/s
 - How many Flops per cycle per core is that? -

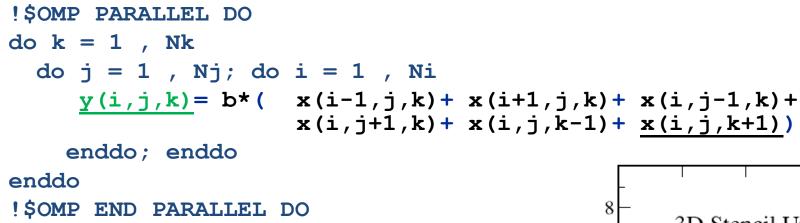
t?
$$\frac{1536 \cdot 10^9 \frac{Flops}{s}}{20 \text{ cores } \cdot 2.4 \cdot 10^9 \frac{Cy}{s}} = 32 \frac{Flops}{cy \cdot core}$$

- Typical duration of a double precision multiply: 4 cycles
 - How much time is that? $\frac{4 cy}{2.4 \cdot 10^9 \frac{cy}{s}} = 1.67 \cdot 10^{-9} s = 1.67 \text{ ns}$
- Basic unit of traffic: Byte
- Unit of bandwidth: Bytes/s
 - Typical memory bandwidth: 160 Gbytes/s = 1.6 · 10¹¹ Bytes/s
 - How many bytes per cycle is that?

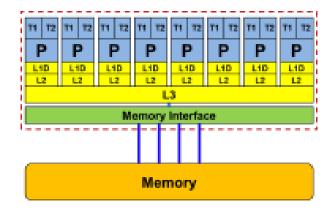
$$\frac{160 \cdot 10^9 \frac{Bytes}{s}}{2.4 \cdot 10^9 \frac{Cy}{s}} = 67 \frac{Bytes}{cy}$$

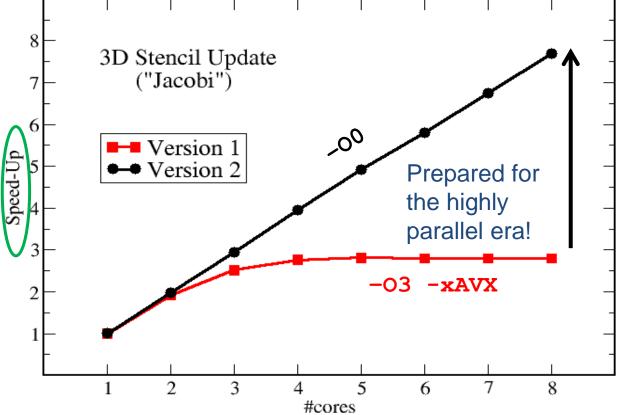
Node-level Performance Engineering Tutorial

Scalability Myth: Code scalability is the key issue

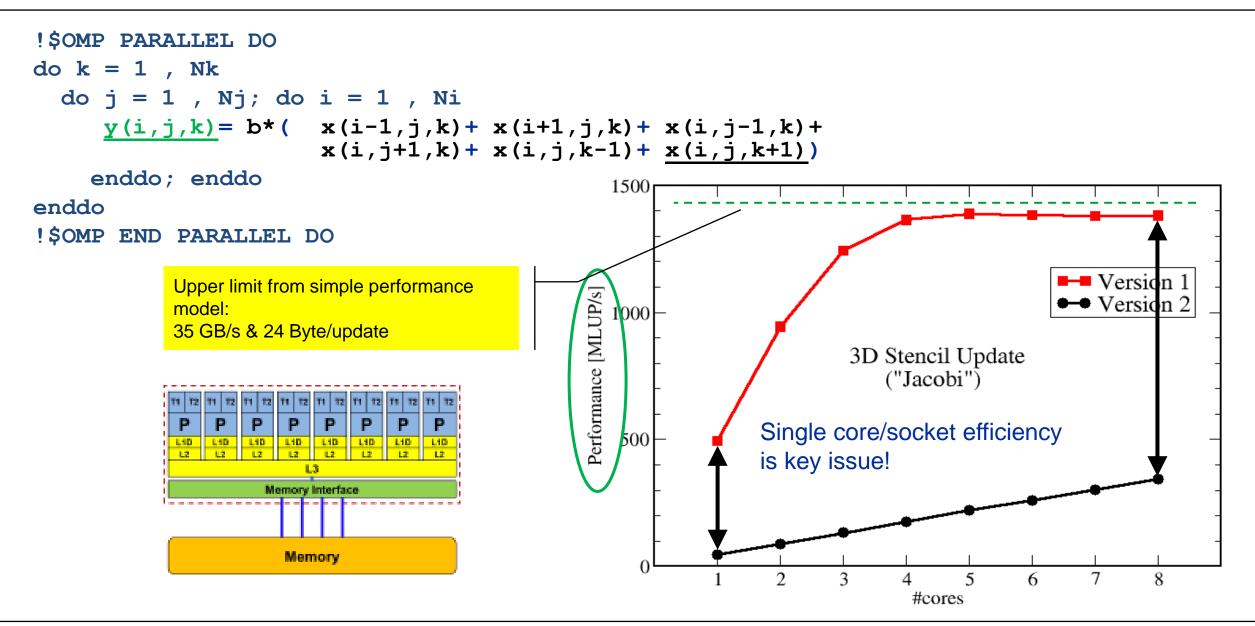


Changing only the compile options makes this code scalable on an 8core chip





Scalability Myth: Code scalability is the key issue



From a student seminar on "Efficient programming of modern multi- and manycore processors"

Student: I have implemented this algorithm on the GPGPU, and it solves a system with 26546 unknowns in 0.12 seconds, so it is really fast.

Me: What makes you think that 0.12 seconds is fast?

Student: It is fast because my baseline C++ code on the CPU is about 20 times slower.

Questions to ask in high performance computing

- Do I understand the performance behavior of my code?
 - Does the performance behave in accordance with a model I have made?
- What is the optimal performance for my code on a given machine?
 - High Performance Computing == Computing at a bottleneck
- Can I change my code so that the "optimal performance" gets higher?
 Circumventing/ameliorating the impact of the bottleneck
- My model yields wrong predictions what's wrong?
 - This is the good case, because you learn something
 - Performance monitoring / microbenchmarking may help clear up the situation

Node-level Performance Engineering Tutorial