Unit 1, Part 2 prolog

Introduction to High Performance Computing

A Blue Waters Online Course
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Course overview

• Introduction to central concepts, the hardware and software environments, and selected algorithms and applications of high performance computing
  – especially high performance computational science and engineering
  – emphasis on tightly coupled computations that are capable of scaling to thousands and even millions of processor cores

• Range of course material
  – some *high-level* surveys of motivating applications (like Part 1 of this unit, a case study motivated by computational aerodynamics)
  – some *low-level* details of implementation (examples to come)
  – most of the time *in between* analyzing parallelism in algorithms (today)

• Students run some demonstration codes provided and do a modest amount of their own programming
  – using PETSc, the "portable, extensible toolkit for scientific computing" (which is a high-level applications programmer interface for distributed memory programming)
Course flavor

• Targeting “parallel computer literacy”
  – develop intelligent critics and consumers
  – future developers of the infrastructure from CS and math
  – applications scientists and engineers, as well
  – acquaint student researchers with what is available in standard open-source parallel scientific software
    • what it can do for us
    • how it works
    • how it is layered and composed

• Scientific computing-oriented
  – crux of motivation for much of supercomputing!
  – scientific computing is the 1% that used to drive the 99% but is now increasingly driven by it
Pedagogical philosophy

- We will spiral-staircase through the material
- Each sector of the staircase is subject matter (algorithm, architecture, application, software, etc.)
- Each time we reach a new level with one sector, we are ready to revisit the next sector on a higher level
Review of Part 1 case study

• Application
  – opportunity for real-time computational aerodynamics
  – penetration of CFD into airplane design

• Architecture
  – limiting nature of speed of electrical signal propagation
  – pipelining
  – parallelism
  – Moore’s Law (1965)

• Algorithm
  – discretization of conservation laws
  – limiting nature of speed of physical signal propagation
  – Courant-Friedrichs-Levy stability criterion (1928)
  – Amdahl’s Law (1967)