Discussion of Vector-based Computers and Applicability of Different Types of Programs

Weston Lahr & Matt Myers
Agenda

• Vector Processor vs Super Scalar
• Scientific Programs
• Evaluation Metrics
• Results & Analysis
• Closing Comments
Super Scalar

- MIMD
- Often COTS
- Memory Hierarchy
  - Memory cache
  - Internode shared memory or communications link
- More General Purpose
- Power3 & Power4 discussed in paper
Vector Processor

- SIMD
- More specialized processors
- Vector registers
- Flat memory (no cache)
- Higher cost than multiple RISC
- NEC SX-6 discussed in paper
  - Used in Earth Simulator
Scientific Programs

• PARATEC
• Cactus
• GTC
PARATEC

• Uses Density Functional Theory (DFT) to find electron wave functions
• DFT used for many problems
  – Nanostructures
  – Semiconductors
• Written in Fortran90
  – Uses MPI
Figure 4: A three-processor example of PARATEC’s parallel data layout for the wavefunctions of each electron in (a) Fourier space and (b) real space.
Cactus

• Used in astrophysics to find numerical solutions to GR
• Simulates astrophysical phenomena
  – Ex black hold evolution
• Uses MPI
Figure 5: Visualization of the grazing collision of two black holes computed by the Cactus code. *(Visualization by Werner Benger/AEI.)*
GTC

• Used in research in magnetic fusion
• Solves equations dealing with turbulence in fusion experiments
• Uses MPI
Figure 7: 3D visualization of electrostatic potential in global, self-consistent GTC simulation of plasma microturbulence in a magnetic fusion device.
Evaluation Metrics

• Gigaflops
• Gigaflops/Processor
• Vector Operation Ratio (VOR)
  – Optimal – 100%
• Average Vector Length (AVL)
  – Optimal (ES) – 256
PARATEC

• Test Case
  – 432 silicon atom bulk systems
• ES
  – 2.6 TFlops for 1024 processors
  – 2.08 GFlops/processor
  – Small test cases prevented valid VOR or AVL
  – Poor scaling due to smaller AVL
• Power3
  – .413 Gflops/P for 512 processors
• Power4
  – 1.08 Gflops/P with 256 processors
• Power3 & Power4 scale poorly too because of communications requirements
Cactus

• Test Case
  – 256x64x64 Grid

• ES
  – 2.70 Gflops/P for 1024 processors
  – 2.7 Tflop/s
  – VOR of 99%
  – AVL of 248 (256 optimal)

• Power3
  – 0.60 Gflops/P with 1024 processors.

• Power4
  – 0.556 Gflops/P with 16 processors
  – Results for more processors on the Power4 were unavailable due to a lack of high-memory nodes.

• Problem size made a big difference with ES because of lower AVL
GTC

• Test Case
  – 4 million particles and 1,187,392 grid points over 200 time steps
• ES
  – 0.701 Gflops/P
  – VOR of 98%
  – AVL of 186
• Power3
  – 153 Mflops/s
• Power4
  – 277 Mflops/s
• Power3 & Power4 exhibit superlinear scaling probably due to cache hits
• SX-6 did not scale as well
Closing Comments

• Vector based computers not as general purpose as super scalars
• Very effective for particular types of problems
• Not going away anytime soon
Works Cited


Questions?