Atmospheric Modeling on the Argonne SP1

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Overview

- Motivation
- NCAR Community Climate Model (CCM2)
- NCAR Mesoscale Model (MM5)
- Summary

Motivation

Raise computational limits to accuracy and reliability.

- length of simulation
- fineness of resolution
- sophistication of model processes

Computational Limits

Performance

- today: 100 Mflop/sec to 1 Gflop/sec
- needed: 10 Gflop/sec to 100 Gflop/sec and beyond

Memory

I/O

NCAR Community Climate Model (CCM2)

Developed at National Center for Atmospheric Research in late 1970s.

Current version CCM2 (Fall 1993)

Climate change and global warming

Current "Modestly Parallel" version

- 1.2 Gflop/sec on Y-MP/8
- 100 year simulation = 15 cpu-days

Parallel Community Climate Model (PCCM2)

NCAR, ANL, and ONRL developing jointly under Dept. of Energy CHAMMP program.

Data domain decomposition and message passing.

Implemented on:

- Intel DELTA / Paragon
- Kendall Square
- Thinking Machines CM2/CM5 (SIMD version)
- IBM SP1

Sustained performance 1.1 Gflop/sec on Intel DELTA (512 nodes)

[P]CCM2

Model of atmospheric component of Earth's climate

Two main components:

- Dynamics
  - Advection (movement) of atmospheric quantities
  - Spectral Transform Method (U,V,T,Ps)
  - Semi-Lagrangian Transport (Q)
- Physics: solar radiation, clouds, precip., etc.

Flow through model

Dynamics

Spectral Transform (U,V,T,Ps)

- horizontal data dependencies in Fourier and Legendre transforms
- parallel or transpose-sequential FFT (east-west)
- distributed vector sum (north-south)

Semi-Lagrangian transport (Q)

- eliminates negative moisture
- poles require distant communication
- implemented using ghost points
- fully semi-Lagrangian CCM2 planned

[P]CCM2 Physics

Perfectly parallel (no horizontal dependencies)

Subject to inefficiency due to load imbalance.

- One-third of time spent in physics (10 percent overall) is lost to load imbala nce.
- imbalance associated with
  - surface type
  - weather patterns
  - polar night
  - solar radiation

Load balancing library.

Porting to the SP1

Message passing

- DELTA: PICL – NX
- SP1: PICL – Chameleon – EUI-H

Compilation issues

Environment

- develop on workstations
- memory for single node runs
- dbx!

I/O

- O_DEFER mode for asynch. output
- parallel I/O using Vesta

CCM Performance

Early results showed node performance

EUI-H and switch give competitive latency and bandwidth

NCAR Mesoscale Model (MM5)

nothing here yet.

MM5 Performance

Mapping to nodes appears to affect switch performance

Summary

SP1 Advantages

- Large node memory
- Good single node performance
- EUI-H is competitive for IPC
- robust operational and programming environment
- I/O Bandwidth
- disk-per-node for out of core
- cost-performance

Summary (cont)

SP1 Disadvantages

- still new
  - services and policies
  - robustness
- node mapping affects switch performance
- SPMD jobs are susceptible to competition for CPU, bandwidth