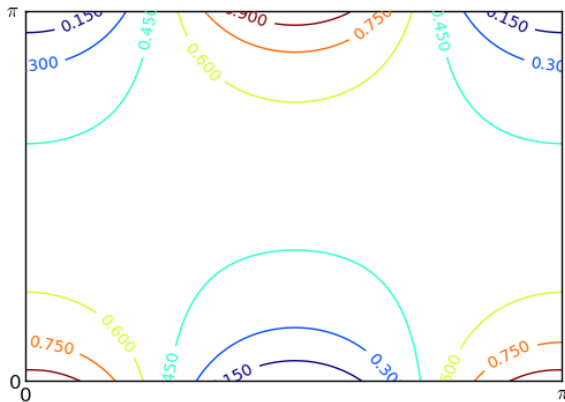# APC 524 – Homework 4

Tom Bertalan

The solution at $t = 0.5 \, \pi^2 / \kappa$ had an average of about 0.49, and had the appearance of a smooth transition from the squared-cosine function along the bottom edge to the square-sine function along the top.

Contour plot of solution after final timestep.

Serial

The serial program benefited dramatically from including the level-2 optimization flag in calls to the g++ compiler—there was a 6.96-times speedup for the 1024x1024 problem.
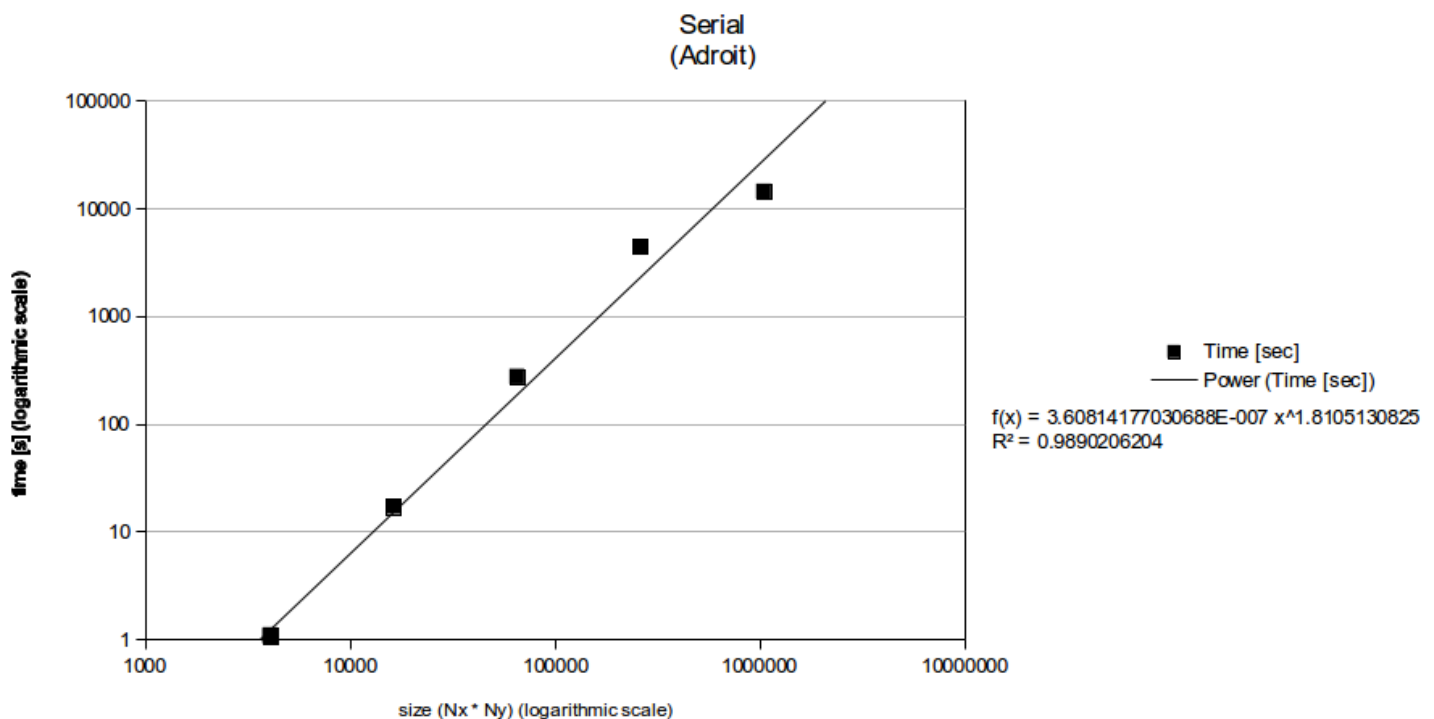
OpenMP

The OpenMP version was recommended by its ease of implementation—a single #pragma preprocessor directive and an extra flag in the makefile were all that was really required to transform the serial program into a parallelized OpenMP program, although code was also added to handle the new number-of-threads command-line argument.

MPI

The MPI (OpenMPI) version had more predictable speed-up with increasing number-of-threads, but was hindered by the complexity of its implementation and therefore its reduced readability. As the problem size became large, the distributed-memory nature of the MPI version became a significant advantage over the OpenMP version.

Serial
(Adroit)

f(x) = 3.60814177030688E-007 x^1.8105130825
R² = 0.9890206204

OpenMP (log/log)
(Adroit)

time [s] (logarithmic scale)

size (Nx * Ny) (logarithmic scale)

2 threads
Power (2 threads)   R² = 0.924080808239
4 threads
Power (4 threads)   R² = 0.999351280807
8 threads
Power (8 threads)   R² = 0.933560202032
16 threads
Power (16 threads)
f(x) = 5.6689398491286E-006 x^1.4462239974
R² = 0.991049381814
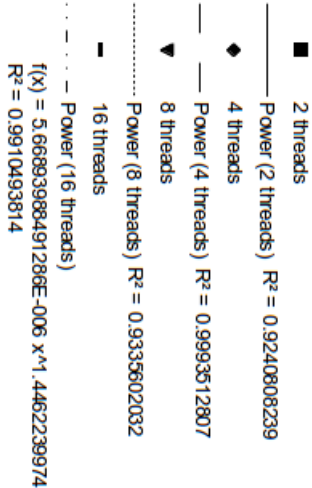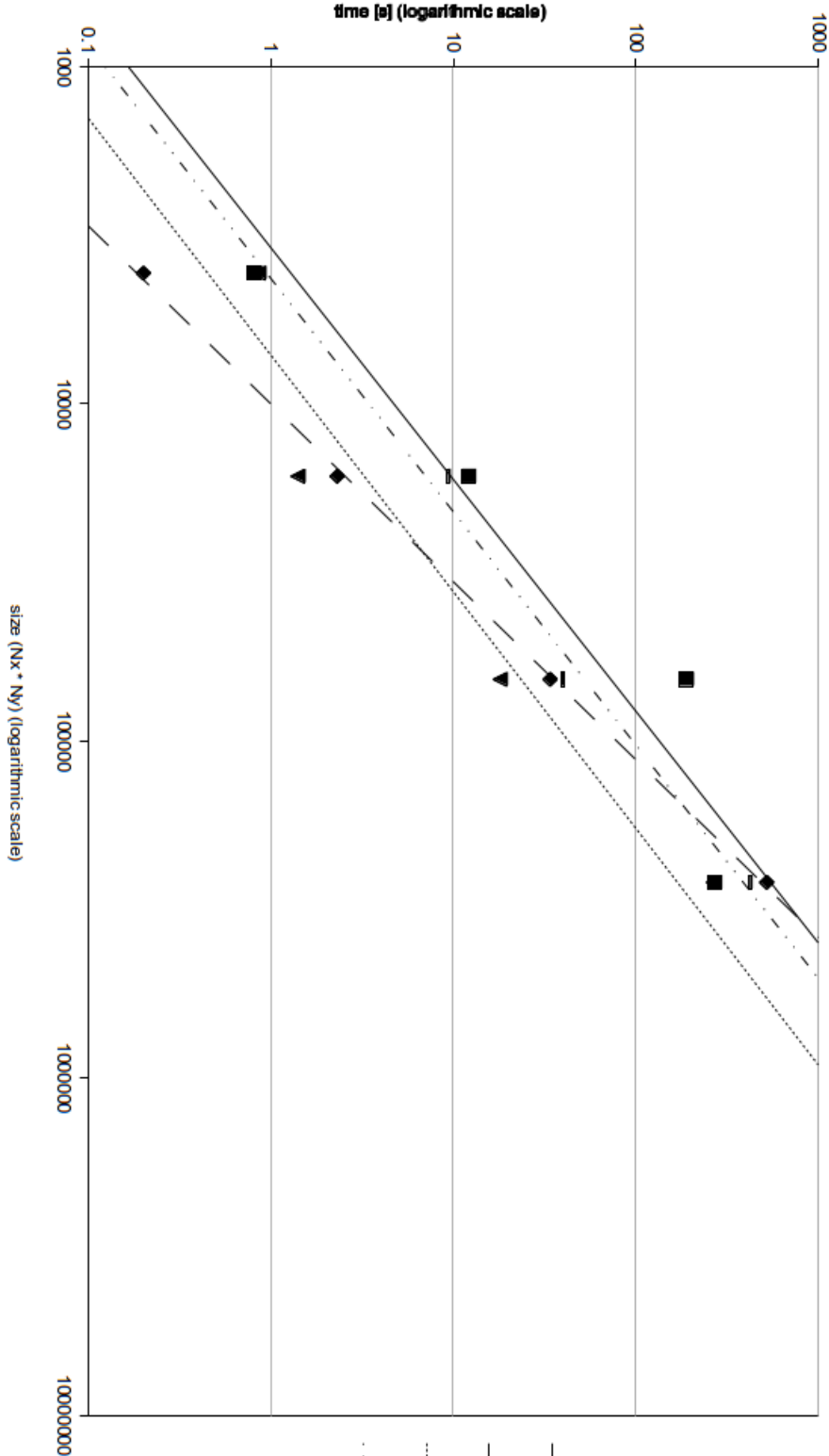
MPI - log/log
(cc2, in Alabama)

time [s] (logarithmic scale)

size (Nx * Ny) (logarithmic scale)

Legend:

- 1 thread
- · · · · · Power (1 thread)
  $f(x) = 8.35334945972121E{-}007\ x^{1.7225538679}$
  $R^2 = 0.98891555$
- ■ 2 threads

- —— Power (2 threads)
  $f(x) = 1.53835172685387E{-}006\ x^{1.5997385268}$
  $R^2 = 0.97650114417$
- ◆ 4 threads

- — — Power (4 threads)
  $f(x) = 8.77416087915029E{-}006\ x^{1.3794103303}$
  $R^2 = 0.9847363761$
- ◄ 8 threads

- · · · · · · Power (8 threads)
  $f(x) = 2.43413226584068E{-}006\ x^{1.47409006}$
  $R^2 = 0.976516289$
- ▬ 16 threads

- – · · – Power (16 threads)
  $f(x) = 0.000003508\ x^{1.4384964226}$
  $R^2 = 0.96135687$

MPI

(cc2, in Alabama)

time [s]

0   50   100   150   200   250   300   350   400   450

size (Nx * Ny)

0   50000   100000   150000   200000   250000   300000

- - - · · - 16 threads

——— 4 threads

- · - · - 1 thread

··········· 8 threads

——— 2 threads