Parallel programming topics exam

Your name:

1 Single processor architecture

Give at least two examples of parallelism inside a single processor socket.

2 Parallel computer architecture

Give an example of an algorithm that can not be made to have perfect speedup. Justify your answer.

3 Parallel computing

Do a scalability (speedup and efficiency) analysis of an OpenMP loop that contains a critical section. Assume the loop body takes time 1 sequentially, of which a fraction f is outside the critical section. Assume the number of iterations n is a multiple of the number of threads p. Also assume the default static distribution of loop iterations over the threads.

4 Computer arithmetic

For real numbers x, y, the quantity $g = \sqrt{(x^2 + y^2)/2}$ satisfies
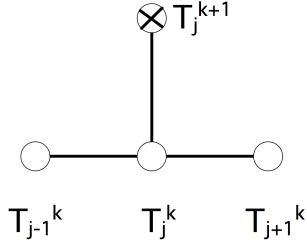
$$g \leq \max\{|x|, |y|\}$$

What can go wrong if you compute g using the above formula? Can you think of a better way?

5 Sparse matrices

Why is a matrix-matrix multiplication routine harder to write for sparse matrices than for dense?

6 PDEs

The explicit Euler method for the one dimensional heat equation (that is, one space and one time dimension) can be pictured as follows:

or in formula:

$$T_j^{k+1} = T_j^k + c_1(T_{j-1}^k - 2T_j^k + T_{j+1}^k) + c_2 \qquad \text{for } j = 1,\ldots,N-1 \text{ and } k = 1,2,\ldots$$

(assume that T_0^k and T_N^k are given for all k, and T_j^1 is given for all j).

1. Suppose there are N space points (the j-coordinate), and P processors. The space points are split $0 = i_0 < i_1 < \cdots < i_P = N-1$, and each processor p computes the values T_i^k for $i = i_{p-1}+1,\ldots,i_p$ and all k.
   How much data does a processor need to exchange before it can compute the next k-step?
2. Describe an algorithm that allows processors to communicate only once every 3 k-steps.
3. Analyse in terms of α, β, γ parameters when this scheme is better than the original.