Lecture 3: Writing Parallel Programs
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Announcements

- Deepthought2 (dt2) accounts have been mailed to everyone
- If you want to use your own account, read the Piazza post and follow instructions
Writing parallel programs

• Decide the serial algorithm first

• Data: how to distribute data among threads/processes?
  • Data locality: assignment of data to specific processes to minimize data movement

• Computation: how to divide work among threads/processes?

• Figure out how often communication will be needed
Two-dimensional stencil computation

- Commonly found kernel in computational codes
- Heat diffusion, Jacobi method, Gauss-Seidel method

2D stencil iteration in parallel
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• 1D decomposition
  • Divide rows (or columns) among processes
2D stencil iteration in parallel

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- 2D decomposition
  - Divide both rows and columns (2d blocks) among processes
2D stencil iteration in parallel

- **1D decomposition**
  - Divide rows (or columns) among processes

- **2D decomposition**
  - Divide both rows and columns (2d blocks) among processes
N-body problem

N-body problem

- Simulating the movement of N-bodies under gravitational forces

N-body problem

• Simulating the movement of N-bodies under gravitational forces

• Naive algorithm: O(n^2)
  • Every body calculates forces pair-wise with every other body (particle)

Data distribution in N-body problems

- Naive approach: Assign \( n/k \) particles to each process
- Other approaches?

http://datagenetics.com/blog/march22013/
https://en.wikipedia.org/wiki/Z-order_curve
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Space-filling curves
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Data distribution in N-body problems

- Let us consider a two-dimensional space with bodies/particles in it
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Data distribution in N-body problems

• Let us consider a two-dimensional space with bodies/particles in it

Quad-tree: not all nodes are shown
Load balance and grain size

• Load balance: try to balance the amount of work (computation) assigned to different threads/processes
  • Bring ratio of maximum to average load as close to 1 as possible
  • Secondary consideration: also load balance amount of communication

• Grain size: ratio of computation-to-communication
  • Coarse-grained (more computation) vs. fine-grained (more communication)
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