No cutoff (all-pairs) Normal Algorithm

CA Algorithm

Cutoff (1D) Assumptions
1. Particles are uniformly distributed.
2. Cutoff distance spans multiple processor areas.
3. Particles have 1D coordinates.

Algorithm
Let \( r_c \) denote the cutoff distance.

Cutoff (2D) Assumption: Particles have 2D coordinates.

Algorithm
Let \( m \) denote the number of processors spanned by \( r_c \).
- Replicate over \( c \) layers
- Shift team particles along diagonal
- For \( (2m+1)^2/c \) steps:
  - Shift replicas by a constant amount
  - Compute interactions
  - Reduce across column

Bounds
\[
L' : \frac{p}{c^2} = \frac{1}{c^2} L, \quad B' : \frac{n}{c} = \frac{1}{c} B
\]

Performance

Conclusions
- Communication Avoidance decreases overall execution time for communication-bound problems (few particles and many processors).
- We observed up to 9.76x speedup over the naive version.
- CA N-Body allows tuning of replication factor (\(c\)) in cases where cost of reduction comprises most of the communication cost.