Review

- What are the most important concepts that you learned in this course?

Review

- Shared memory vs. distributed memory
- OpenMP vs. MPI
- Performance modeling: is the code as fast as it could be *on a given machine*? What are the bottlenecks, computation or data movement (bandwidth and latency)?
- Improving latency:
  - exploit data locality/caches
  - use multiple threads to hide latency
- MIC-KNC/GPUs are used as coprocessors and accelerators
- Interconnects and topologies: cost vs. performance
  - Fat trees are common for commodity clusters
- Scalable algorithms are needed for large problems
  - e.g., cell lists, FFT, etc.

Designing parallel programs

- How to partition the problem?
  - Not difficult for regularly structured problems
  - Various partitioning algorithms for unstructured problems
- How to lay out the data for better data locality?
- Use kernels that already have fast implementations (e.g., BLAS)

Some algorithms

- Two algorithms for distributed matrix multiplication
  - Cannon and SUMMA
  - Can reduce communication by using additional copies of the data
- Sparse matrix-vector product
- Algorithms for collective communications
  - Binomial trees, recursive doubling, etc.
- Algorithms for particle simulations

Trading performance and programmability: Two examples

- Map Reduce
  - Easy distributed memory programming that can be applied to many problems
  - Example: count the total number of occurrences of the word “selfie” in all web pages
    - Map operation: web page → word count
    - Reduce operation: sum all word counts
- Parallel Computing in Matlab
  - Parallel computing toolbox
  - Easy example: parfor loops (like parallel openmp loops)

HPC research: enable the solution of very large problems on very large computers

- Motivations
  - Very large problems
    - e.g, entire cell simulations, large molecules, “Big Data”
  - Very large computers
    - e.g., “Exascale” and MIC/GPU (large numbers of cores)
- Solution approaches: both algorithms and implementations
- Application drivers