Wrap-Up

CS315B

Lecture 15

Topics

- Presentations
- Key Ideas
- Predictions

Presentations

Your Presentation Should Include

- Brief problem description
  - Enough for everyone to understand what the computation does

- Parallelization strategy
  - What are the tasks and what are the dependencies?

- Mapping strategy
  - Where did you put tasks and data?
  - If different from the default mapper

- Issues

- Performance results
  - Graphs up and to the right!
  - Profiles
  - Comparisons with reasonable baselines if possible

Your Presentation Should Not Include

- Disproportionate discussion of related work
  - Some context is good, of course

- Gory details
  - Don’t need to see your command line flags

Remember: You have 15 minutes

What is Due?

- Your slide deck
  - Updated with any new results since your presentation
- Your code

Key Ideas:
Parallel Programming

Amdahl’s Law

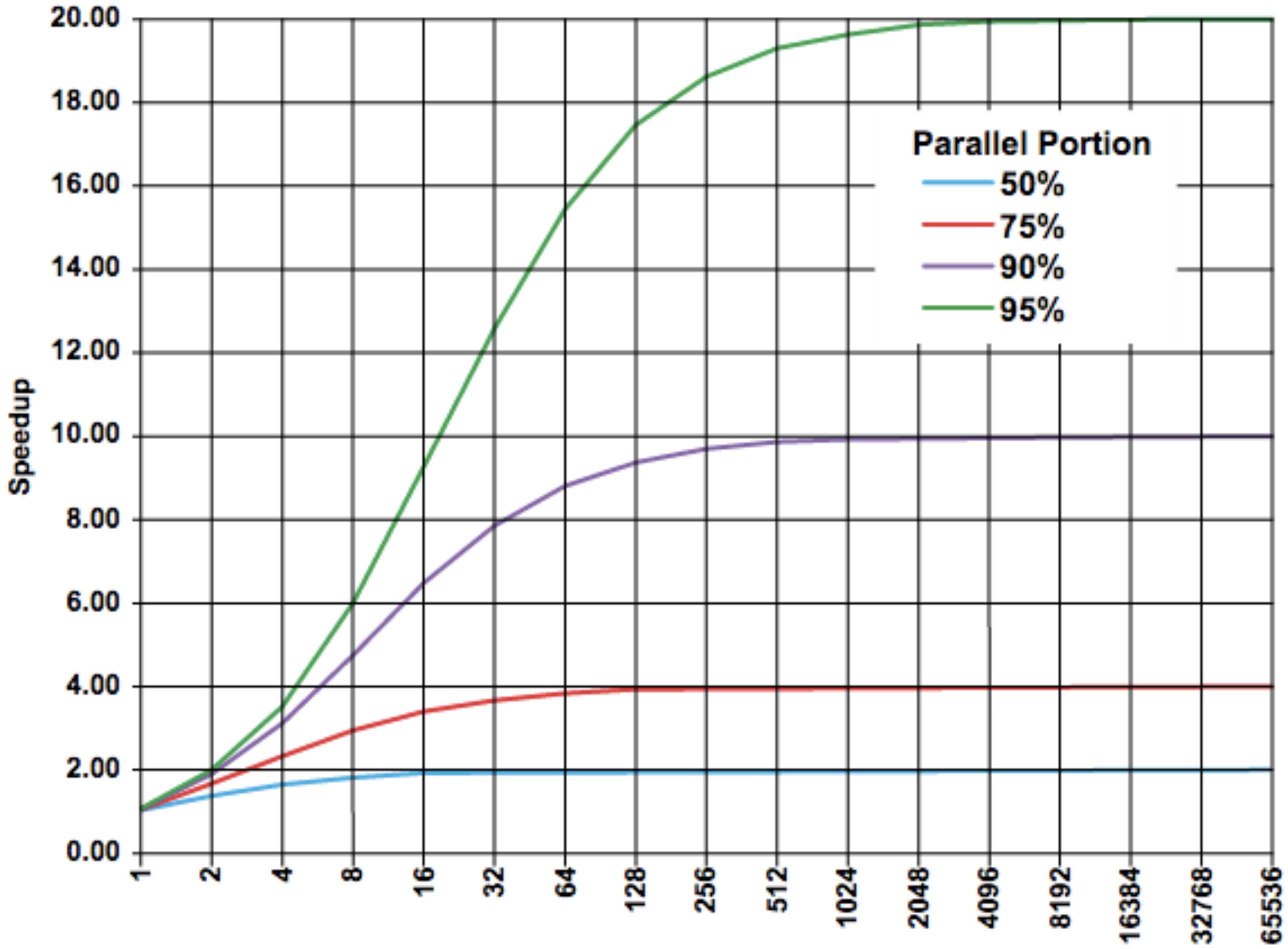
$$\text{Speedup} = \frac{1}{(1 - p) + (p / s)}$$

where

p = portion of the program sped up

s = factor improvement of that portion

Parallelism: Speed vs. # of Processors for Different Values of p



Examples

- What are some examples of Amdahl’s Law?

- Bonus: Have you come across an instance yourself?

Locality

- Machines are hierarchically constructed
  - Small and fast at finest scale
  - Big and slow at coarsest scale
  - Each level is at least 10X

- Locality matters
  - Data and associated compute should be co-located
  - Not a small effect

Locality: Examples

- What are some computations/algorithms with good or bad locality?

Overhead

- Overhead = anything that isn’t application code

- Any system overheads limit scalability

Weak and Strong Scaling

- Weak scaling
  - Increase problem size with node count
    - Problem size per node is constant
  - Characterizes communication behavior

- Strong scaling
  - Problem size is fixed
  - Tests minimum granularity & communication

Surface Area to Volume

- A partitioning into N pieces is better if it requires less communication
- For stencils, communication is proportional to the surface area of a piece
- The volume of a piece represents the total work in that piece

Metaprogramming

- Not specifically for parallelism
  - Or even for performance

- Just a useful idea
  - That is not as well known as it should be

Key Ideas: Tasking

Task-Based Programming

- Tasks = parallel functions

- Collection arguments

- Program is a directed acyclic graph of tasks
  - Edges indicate ordering relationships
  - Can program graphs directly
  - Or write a program to generate graphs

Mapping

- Selecting
  - Where tasks run
  - Where data is placed

- Very important to performance
  - Significant improvements/penalties possible

Partitioning

- To distribute data, it must be partitioned

- Two issues
  - How partitions are named
  - What partitioning operators are available

- Overpartitioning

- Underexplored aspect of parallel programming

The Argument

- Tasking is compositional
  - Natural to compose programs/libraries that use tasks
  - Runtime can extract parallelism across abstraction boundaries

- Mapping is fundamentally not compositional
  - Adding a component may change the mapping for the whole program
  - A resource optimization problem

Predictions

Hardware

- Hardware drives the programming model

- Trends
  - More specialized accelerators
  - More reconfigurable processors
  - Decreasing (or not increasing) memory/thread

- Implication
  - Data movement and placement will be key

Applications

- Who will be the programmers?

- Options
    - Traditional HPC
    - Data analytics

- Likely data analysis >> HPC
    - Even within traditional HPC communities

Programming Systems

- MPI, OpenMP, CUDA are here to stay
    - Nothing goes away
    - E.g., Fortran

- One or two tasking systems will survive
    - And likely succeed
    - Building on top of MPI, OpenMP, CUDA

Why?

- Compositionality
  - Clear composition model
  - Clear mechanism for optimizing whole programs
    - Scheduling ahead
    - Mapping

Cloud vs. Supercomputer

- For small/short projects, the cloud will rule
  - Removes fixed overheads of obtaining and running machines

- For large/long projects, less clear
  - Compute intensive applications can be competitive in the cloud
  - Data intensive applications tend to be too expensive
  - If a project is large enough, it will benefit from its own hardware resources

Open Questions for Tasking Systems

- How well will composing task systems really work?
  - Few actual demonstrations as yet

- How important is resilience?

- Can mapping be automated?

- Can partitioning be automated?

- How low can the overheads be?

- Others?