Parallel & Distibuted Computing: Lecture 5b

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October 9, 2018

Concepts and Terminology

1. Some General Parallel Terminology

2. Limits and Costs of Parallel Programming

Some General Parallel Terminology

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- Coarse: relatively large amounts of computational work are done between communication events
- Fine: relatively small amounts of computational work are done between communication events

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Observed Speedup Observed speedup of a code which has been parallelized, defined as:

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- Parallel overhead related
- Characteristics of your specific application

Limits and Costs of Parallel Programming

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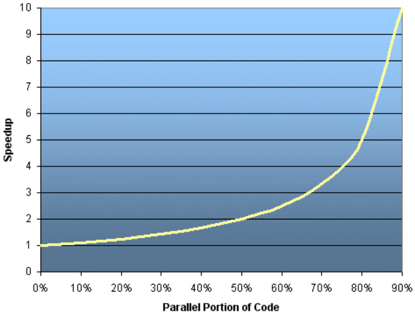
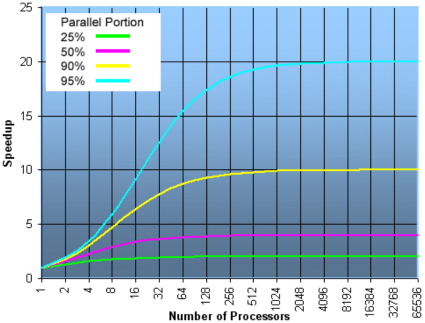
Amdahl's Law states that potential program speedup is defined by the fraction of code (P) that can be parallelized:

$$\text{speedup} = \frac{1}{1-P}$$





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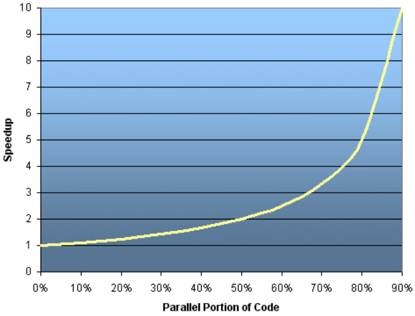

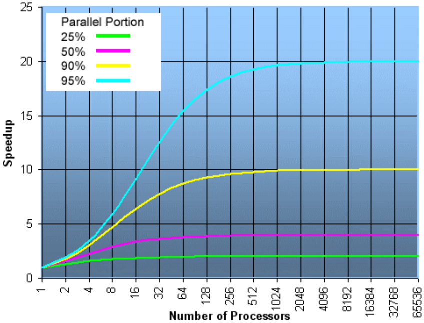

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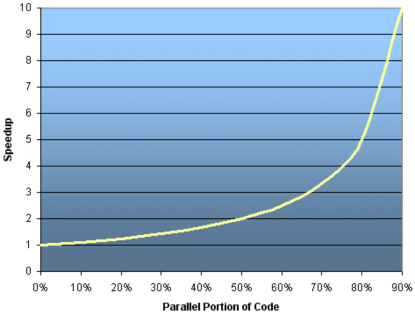

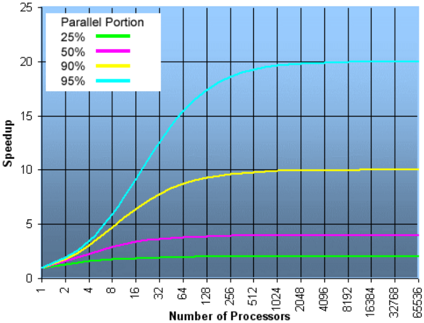

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- If 50% of code can be parallelized, $max(\text{speedup}) = 2$, meaning the code may run twice as fast.

Amdahl's Law 2/4

Introducing the number N of processors performing the parallel fraction of work, the relationship can be modeled by:

$$\text{speedup} = \frac{1}{\frac{P}{N} + S}$$

where $P =$ parallel fraction, $N =$ number of processors and $S =$ serial fraction.

Amdahl's Law 3/4

It soon becomes obvious that there are limits to the scalability of parallelism

For example:

	speedup		
N	P = .50	P = .90	P = .99
10	1.82	5.26	9.17
100	1.98	9.17	50.25
1,000	1.99	9.91	90.99
10,000	1.99	9.91	99.02
100,000	1.99	9.99	99.90

Figure 1: Speedup table

Amdahl's Law 4/4

However, certain problems demonstrate increased performance by increasing the problem size. For example:

```
2D Grid Calculations      85 seconds   85%
Serial fraction           15 seconds   15%
```

We can increase the problem size by doubling the grid dimensions and halving the time step. This results in four times the number of grid points and twice the number of time steps. The timings then look like:

```
2D Grid Calculations      680 seconds   97.84%
Serial fraction            15 seconds    2.16%
```

Problems that increase the percentage of parallel time with their size are more scalable than problems with a fixed percentage of parallel time.

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- Adhering to “good” software development practices is essential when working with parallel applications - especially if somebody besides you will have to work with the software.

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- Hardware architectures are characteristically highly variable and can affect portability.

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- For short running parallel programs, there can actually be a decrease in performance compared to a similar serial implementation. The overhead costs associated with setting up the parallel environment, task creation, communications and task termination can comprise a significant portion of the total execution time for short runs.

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  - Weak scaling: The problem size per processor stays fixed as more processors are added.
- The ability of a parallel program's performance to scale is a result of a number of interrelated factors. Simply adding more processors is rarely the answer.

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- Parallel support libraries and subsystems software can limit scalability independent of your application.