Lecture 2.1
Amdahl's Law

EN 600.320/420

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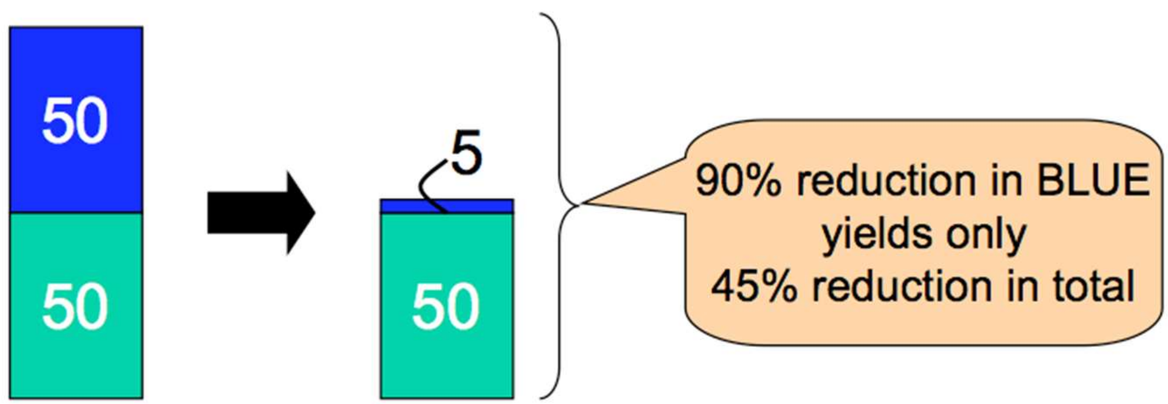
Amdahl's Law

- Improving a portion *P* of a computation by factor *s* results in an overall speedup of

$$S_{\text{latency}}(s) = \frac{1}{(1-p) + \frac{p}{s}}$$

- Paraphrased: speedup limited to fraction improved
  - Obvious but fundamental observation



Amdahl's Law

$$S_{\text{latency}}(s) = \frac{1}{(1-p) + \frac{p}{s}}$$

- *p* is the proportion of execution time that benefits from improved resources, i.e. the parallel part
  - *(1-p)* is the portion that does not benefit; i.e. the serial part
- *s* is the speedup of the optimized part
- $S_{latency}(s)$ theoretical speedup of the whole task

- In practice (for analyzing parallel codes)
  - $S_{latency}(s)$ observed speedup
  - *s* number of resources (cores or processors)
  - *p* is the fraction that runs in parallel
- We use the theory of parallelism (Amdahl's) law to infer parameters/properties of a

Amdahl's Law and Parallelism

- Supposing you want to achieve a speedup of 80 with 100 processors, what fraction of the original computation can be sequential?

Paraphrased from Hennesey and Patterson, *Computer Architecture, 2nd Ed.*

Amdahl's Law and Parallelism

- Supposing you want to achieve a speedup of 80 with 100 processors, what fraction of the original computation can be sequential?

$$\text{Speedup} = \frac{1}{1 - P + \frac{P}{S}}$$

$$80 = \frac{1}{1 - P + \frac{P}{100}}$$

$$P = 0.9975$$

Paraphrased from Hennesey and Patterson, *Computer Architecture, 2nd Ed.*

What is sequential?

- An abstraction to reason about parallelism.
- Sometimes literal:
  - Outer/control thread in OpenMP
  - File system I/O before launching a program
- Sometimes metaphorical:
  - When one/few processes are running and other complete
  - When parallelism introduces additional computation
- The unoptimized fraction of the code
  - When not all resources are doing useful work at full capacity