Chip Multi-Processor

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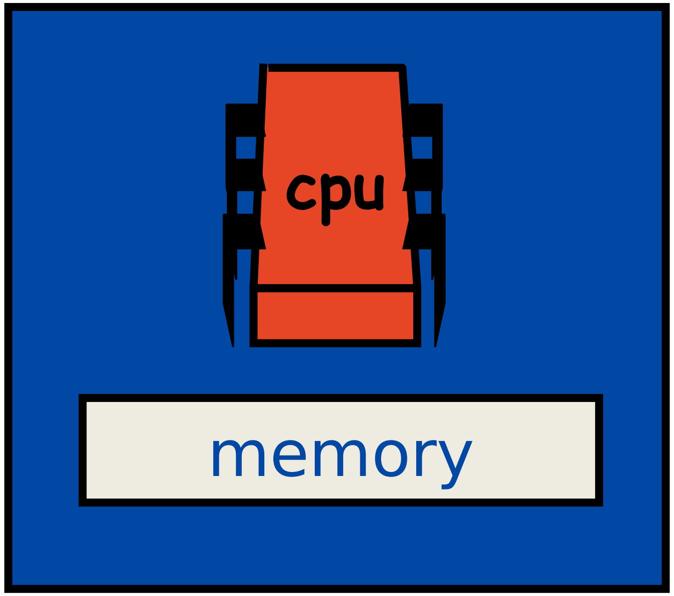
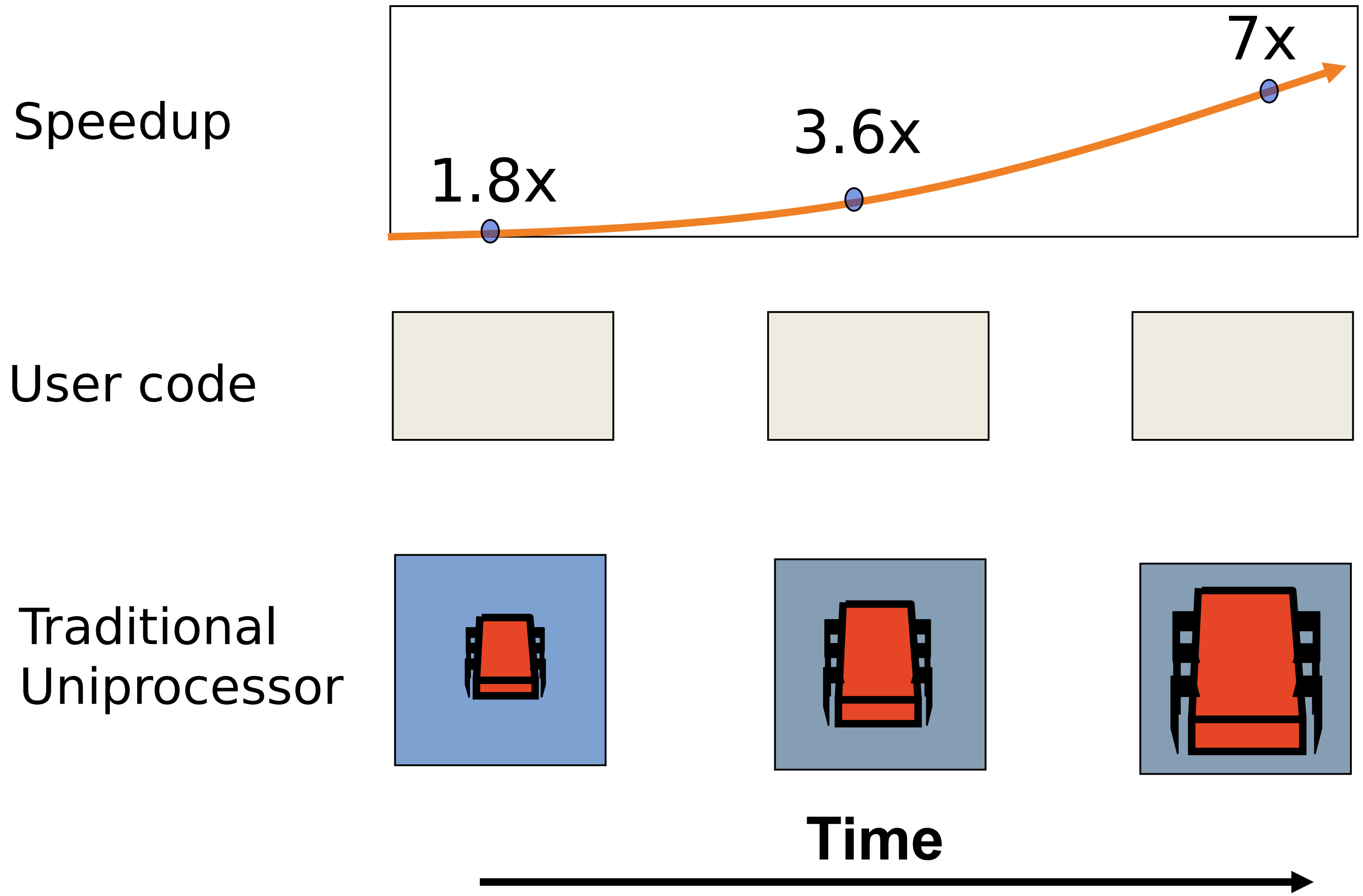
Traditional Uniprocessor

Single Central Processing Unit (CPU), single memory



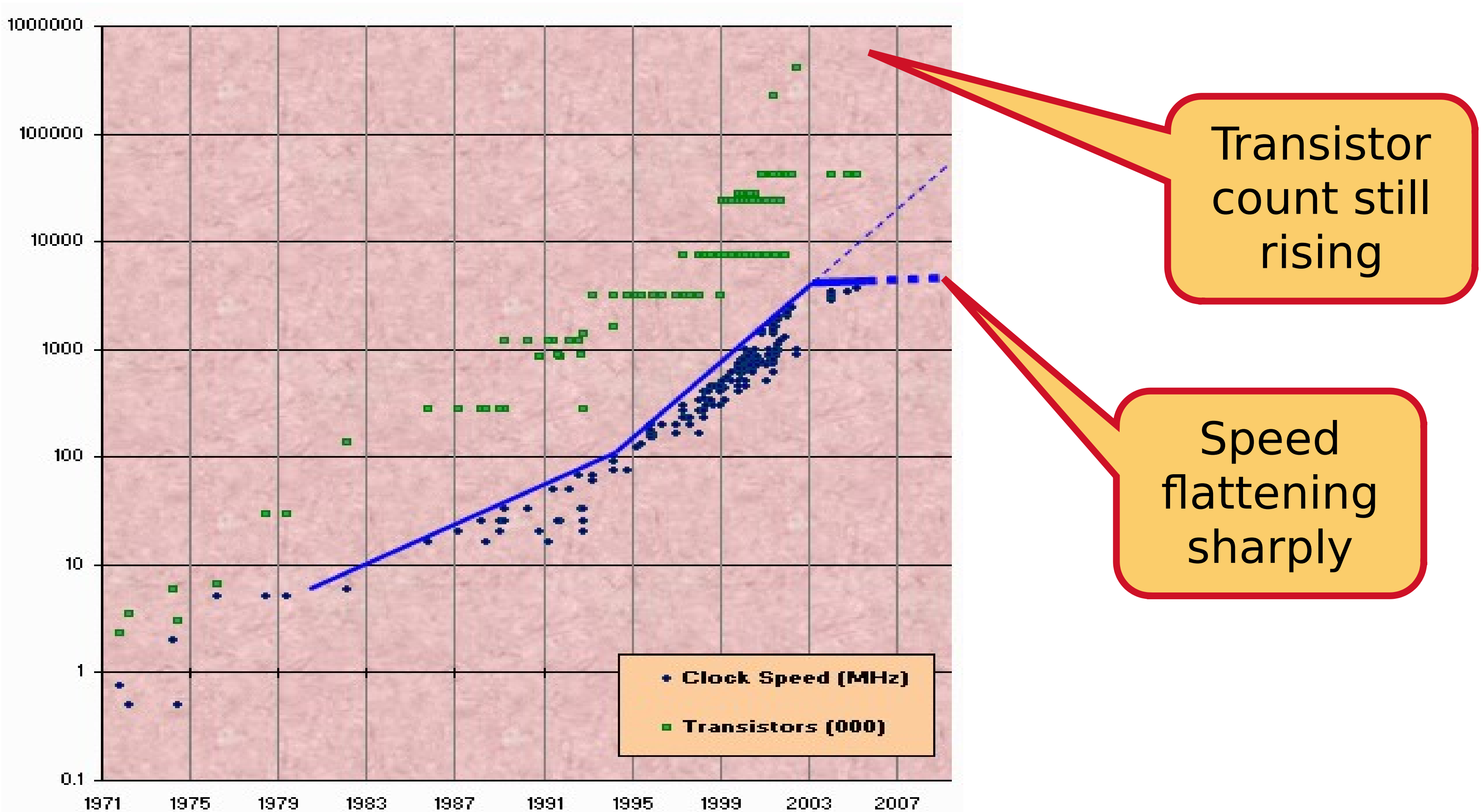
Performance Improvement

Moore's law: *# transistors per chip doubles every 2.5 years*



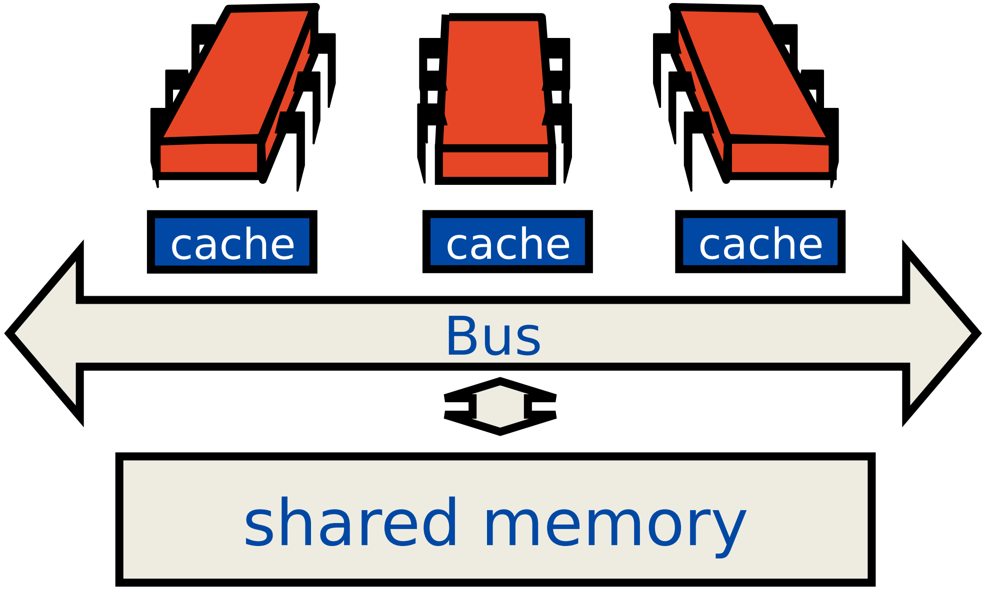
The Free Lunch is Over

But performance no longer increases with # transistors



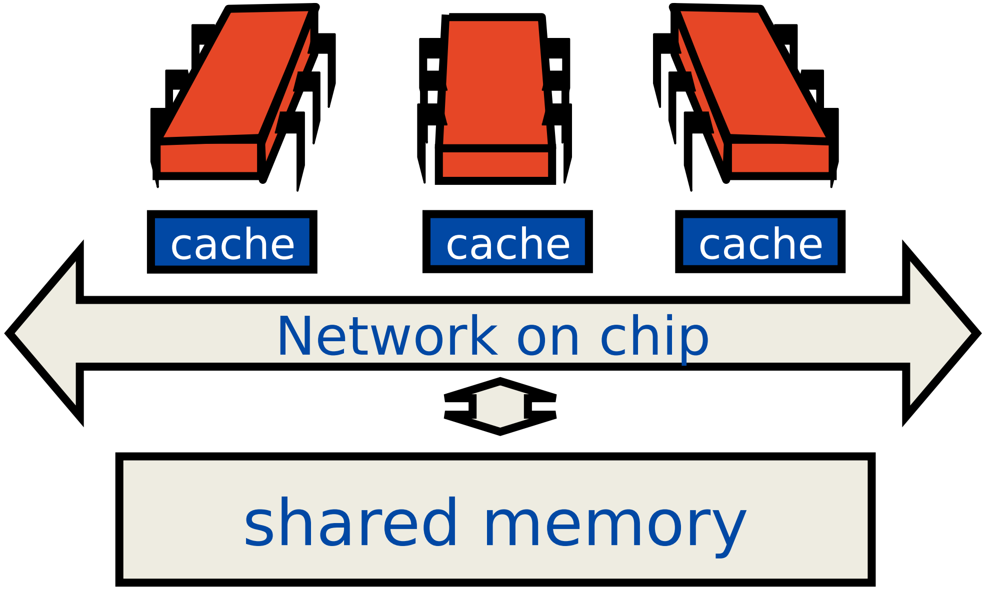
Multiprocessor machine

Symmetric Multi-Processor (SMP)



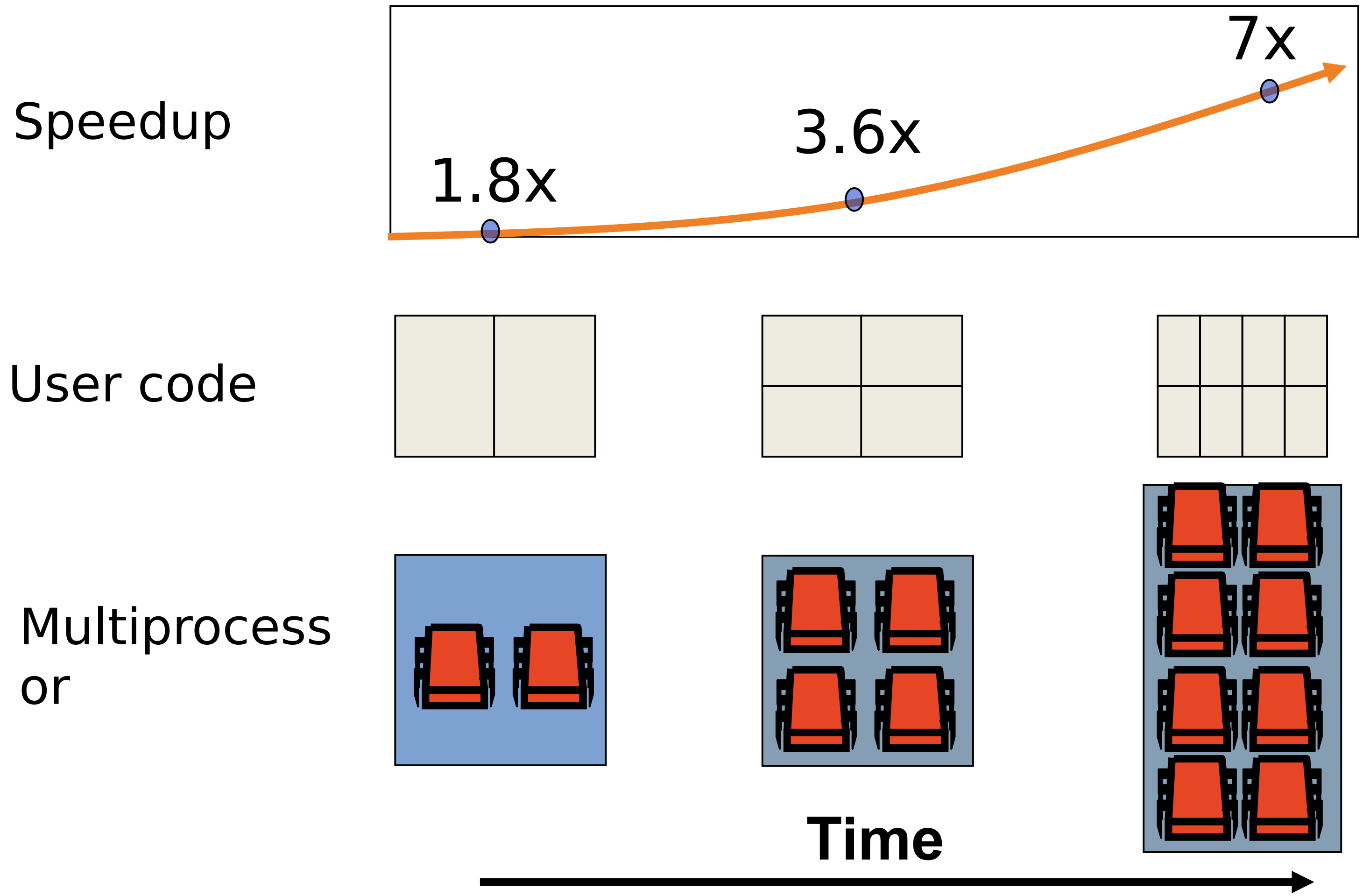
Multicore machine

Chip Multi-Processor (CMP)



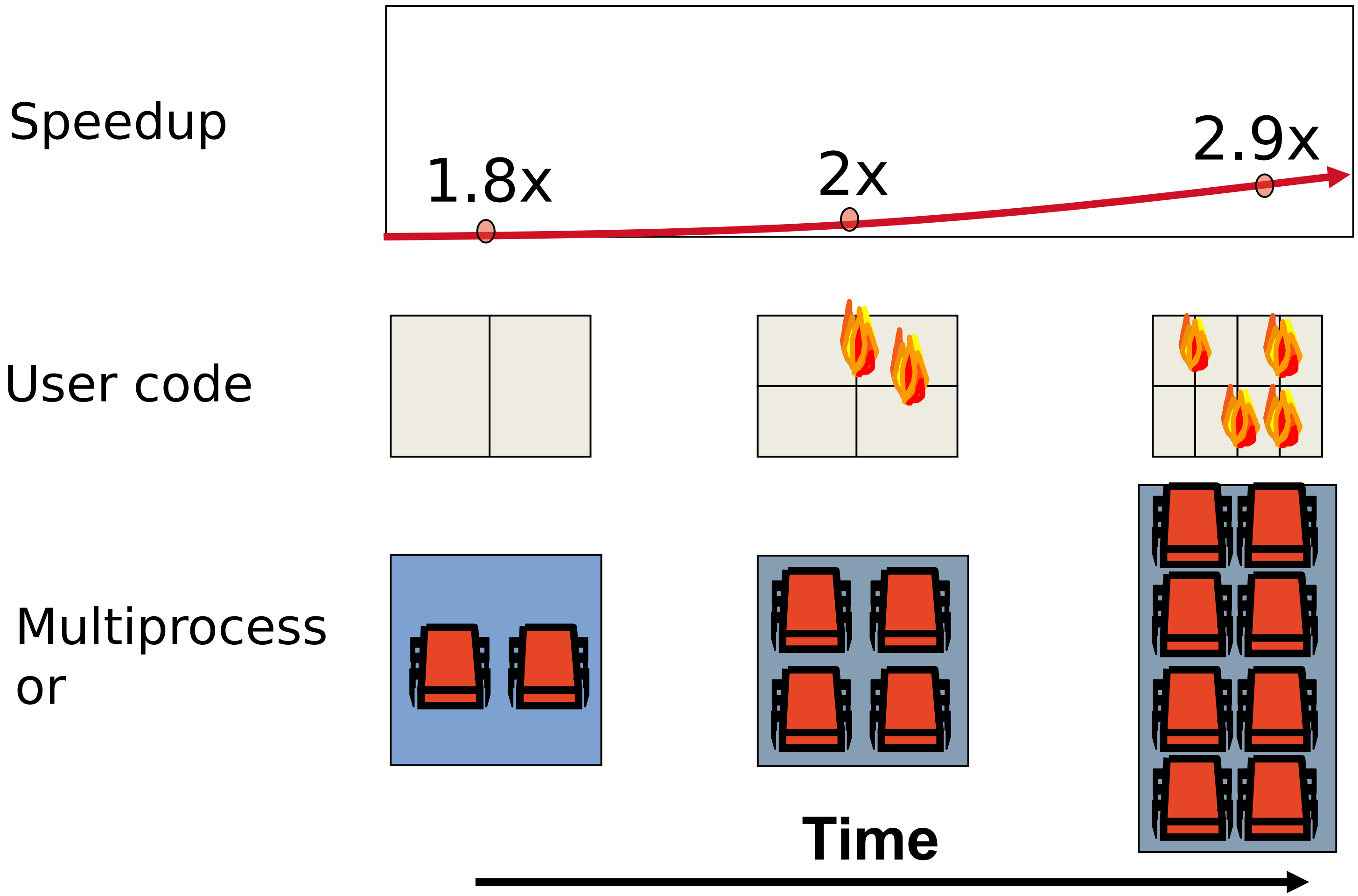
Performance Improvement requires Concurrency

The trend is to multiply the number of CPUs rather than frequency



Not in Reality

Problem: parallelisation and synchronisation require great care…



Amdahl's law

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Amdahl's Law

$$\text{Speedup} = \frac{\text{OldExecutionTime}}{\text{NewExecutionTime}}$$

…of computation given **n** CPUs instead of **1**

Amdahl's Law

$$\text{Speedup} = \frac{1}{1 - p + \frac{p}{n}}$$

Amdahl's Law

$$\text{Speedup} = \frac{1}{1 - p + \boxed{\frac{p}{n}}}$$

Parallel fraction

Amdahl's Law

Sequential fraction

Parallel fraction

$$\text{Speedup} = \frac{1}{\boxed{1-p} + \frac{\boxed{p}}{n}}$$

Amdahl's Law

Sequential fraction

Parallel fraction

$$\text{Speedup} = \frac{1}{\boxed{1-p} + \frac{\boxed{p}}{\boxed{n}}}$$

Number of processors

Example

- Ten processors
- 60% concurrent, 40% sequential
- How close to 10-fold speedup?

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$$\text{Speedup} = 2.17 = \frac{1}{1 - 0.6 + \frac{0.6}{10}}$$

Example

- Ten processors
- 80% concurrent, 20% sequential
- How close to 10-fold speedup?

Example

- Ten processors
- 80% concurrent, 20% sequential
- How close to 10-fold speedup?

$$\text{Speedup} = 3.57 = \frac{1}{1 - 0.8 + \frac{0.8}{10}}$$

Example

- Ten processors
- 90% concurrent, 10% sequential
- How close to 10-fold speedup?

Example

- Ten processors
- 90% concurrent, 10% sequential
- How close to 10-fold speedup?

$$\text{Speedup}=5.26=\frac{1}{1-0.9+\frac{0.9}{10}}$$

Example

- Ten processors
- 99% concurrent, 01% sequential
- How close to 10-fold speedup?

Example

- Ten processors
- 99% concurrent, 01% sequential
- How close to 10-fold speedup?

$$\text{Speedup} = 9.17 = \frac{1}{1 - 0.99 + \frac{0.99}{10}}$$

The Moral

- Making good use of our multiple processors (cores) means
- Finding ways to effectively parallelise our code
  - Minimize sequential parts
  - Reduce idle time in which threads **wait**

Multicore Programming

- This is what this course is about…
  - The % that is not easy to make concurrent yet may have a large impact on overall speedup
- Next week:
  - A more serious look at mutual exclusion