Profiling and Timing your code

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Link to survey on this topic: http://tinyurl.com/rcpresurvey

https://github.com/ResearchComputing/Parallelization_Workshop/tree/master/Day1

Outline

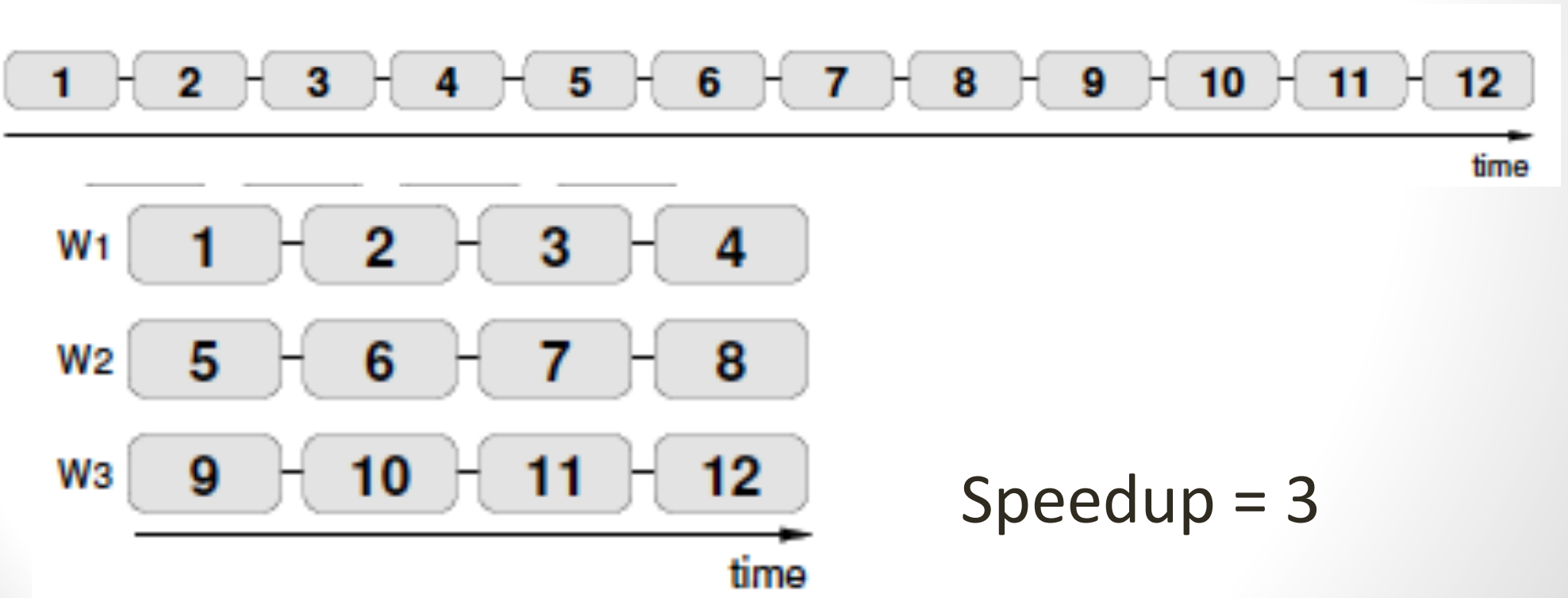
- Why measuring your parallel performance?
- Strong Scaling
- Weak Scaling
- Example measuring your performance
- Memory usage

Why Measure Performance

- Processors are not getting faster
  - Only performance improvement through parallelism
- Guidance on how many cores to use
- Identify bottlenecks in your code
- Have changes improved the performance of the code
- Speedup
  - Increase of performance processing the same problem
  - Parallel computing – using more cores or nodes

Speedup Formula

$$\text{Speedup} = \frac{\text{Sequential execution time}}{\text{Parallel execution time}}$$



Speedup = 3

Execution Time Components

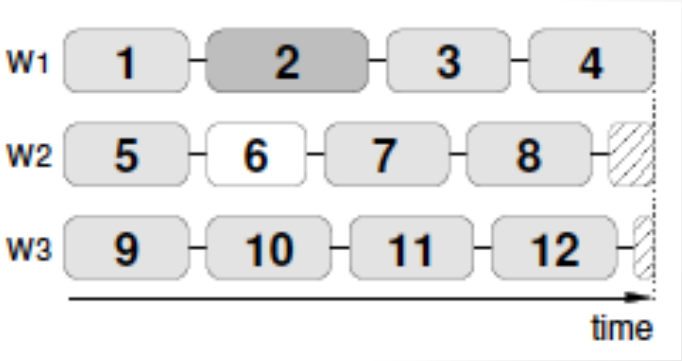
- Inherently sequential computations: $\mathrm{s(n)}$
- Potentially parallel computations: $\mathrm{p(n)}$
- Communication operations: $\mathrm{c(n,\ p)}$

- Speedup expression:

$$S \leq \frac{s+p}{s(n)+p/N+c}$$

Parallel Overhead

- Overhead because of
  - Startup time
  - Synchronizations
  - Communication
  - Overhead by libraries, compilers
  - Termination time
- Other barriers to perfect speedup
  - Not perfectly load balanced



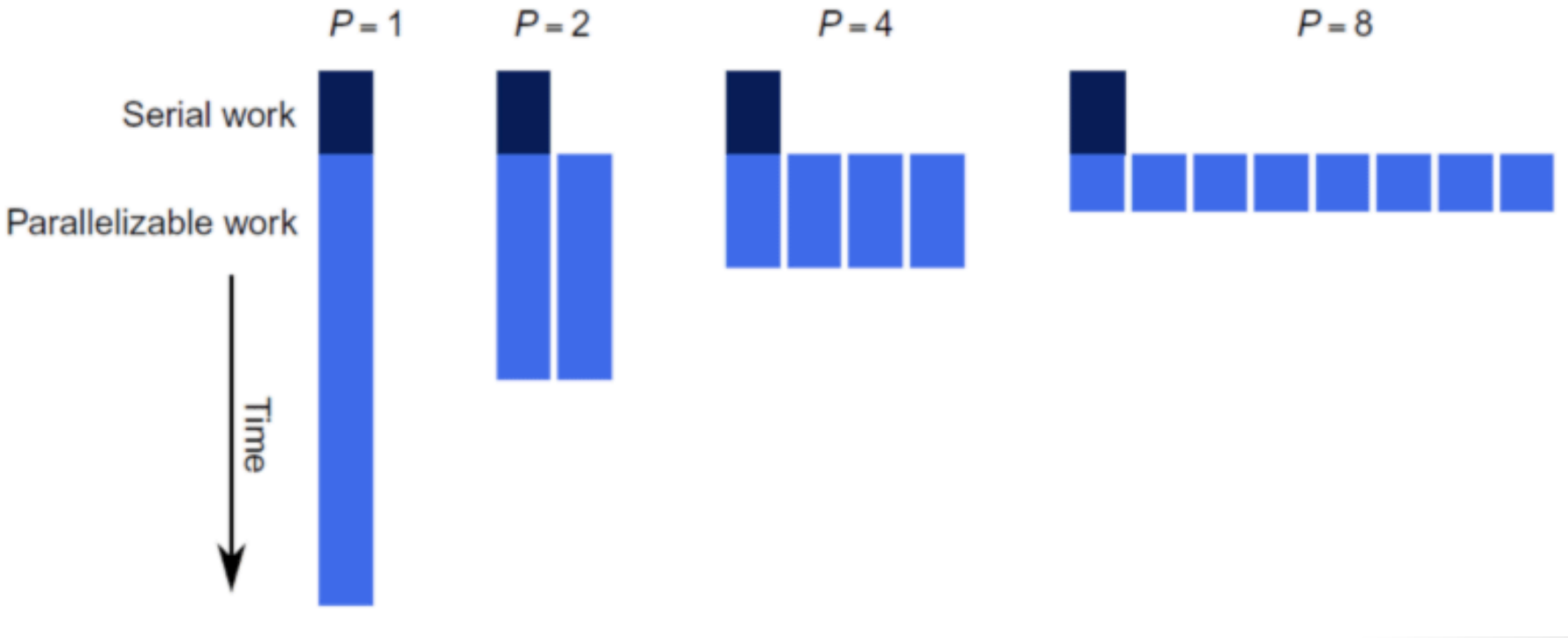
Efficiency

$$\text{Efficiency} = \frac{\text{Sequential execution time}}{\text{Processors} \times \text{Parallel execution time}}$$

$$\text{Efficiency} = \frac{\text{Speedup}}{\text{Processors}}$$

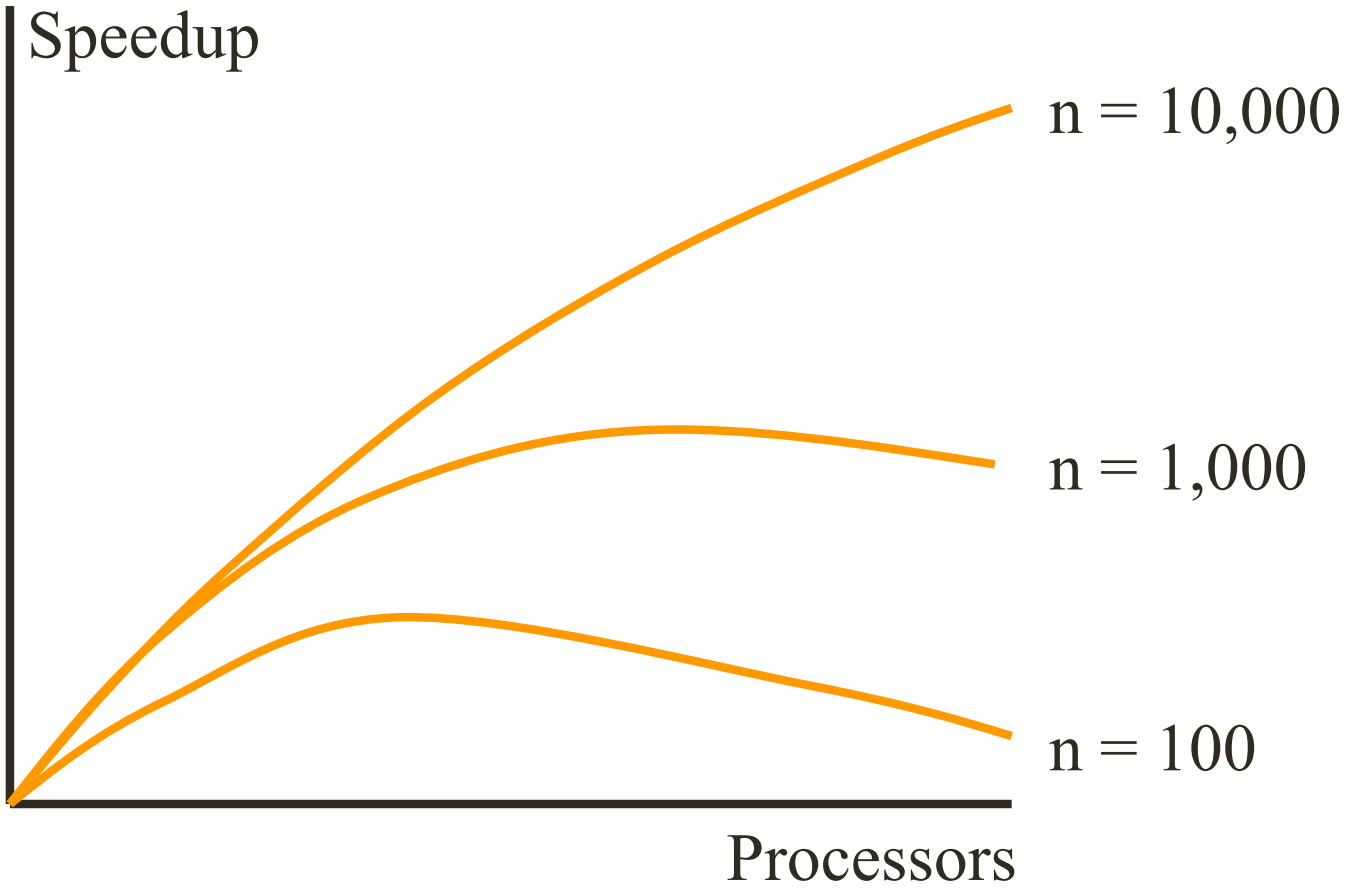
Amdahl's law

- Speedup is limited by the non-parallelizable serial portion of the work



http://www.drdobbs.com/parallel/amdahls-law-vs-gustafson-barsis-law/240162980?pgno=2

Illustration of Amdahl Effect



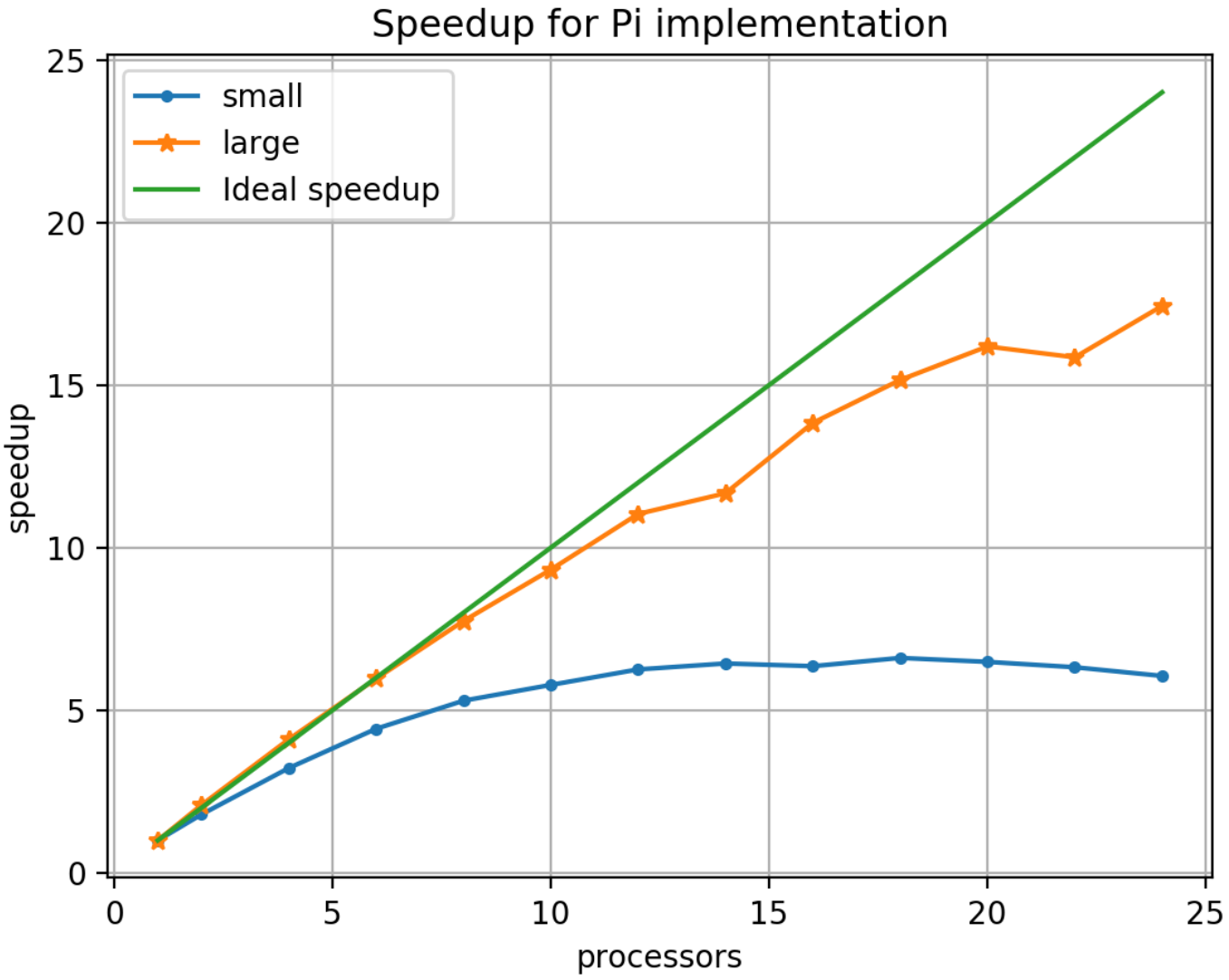
Review of Amdahl's Law

- Treats problem size as a constant
- Shows how execution time decreases as number of processors increases
- Strong scaling
  - Problem size is fixed
  - Number of processor increases

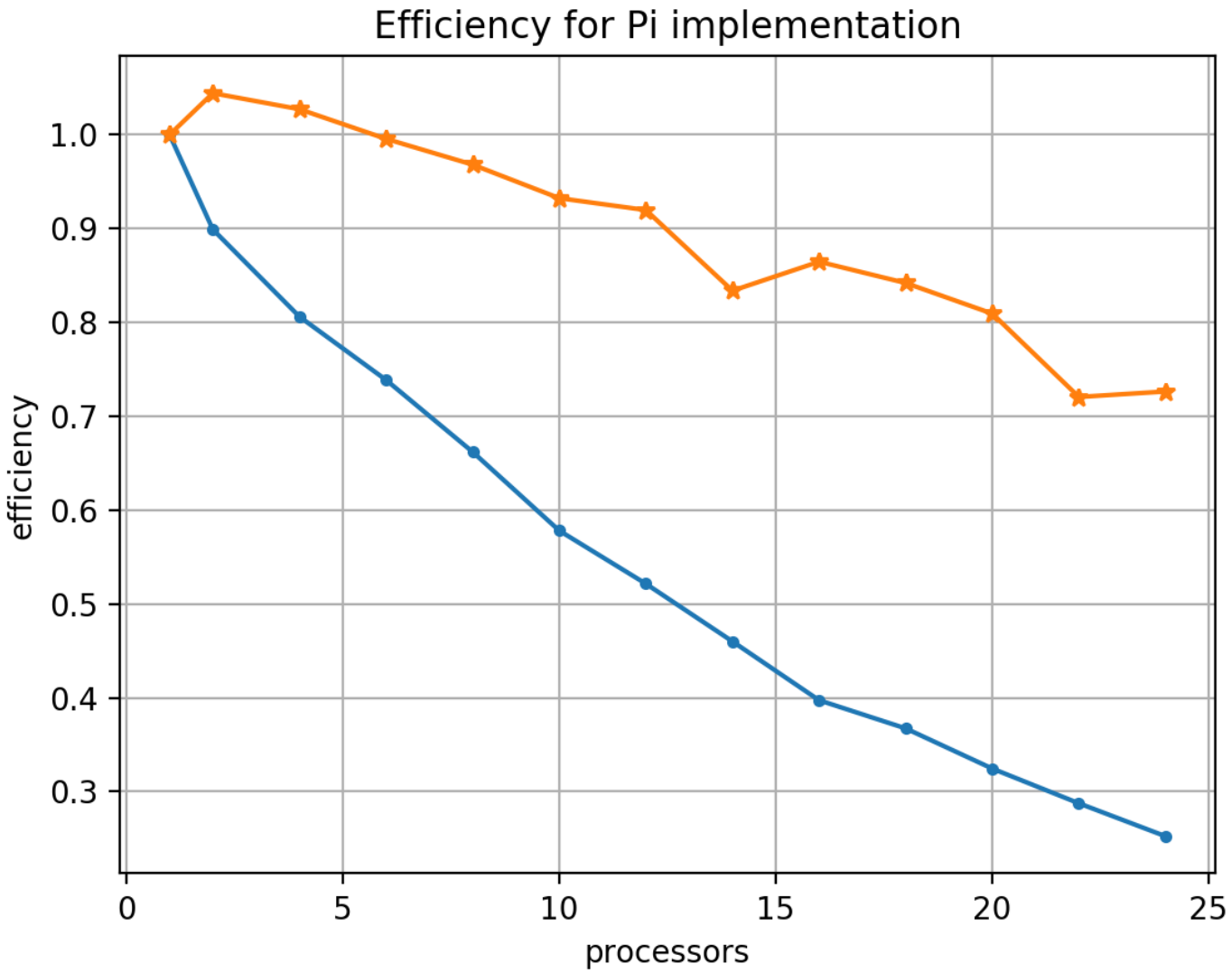
Example

- Parallelizing Pi in python
  - Code in Day1/examples
  - pi_serial.py
  - pi_parallel.py
- Benchmarking on one node
  - 04-serial.sh
  - 04_serial_large.sh
- Strong Scaling
  - 04-strong_scaling.sh
  - 04_strong_scaling_large.sh
- Post processing
  - plot_speedup.py

Speedup


Speedup for Pi implementation
small
large
Ideal speedup
speedup
processors
0
5
10
15
20
25

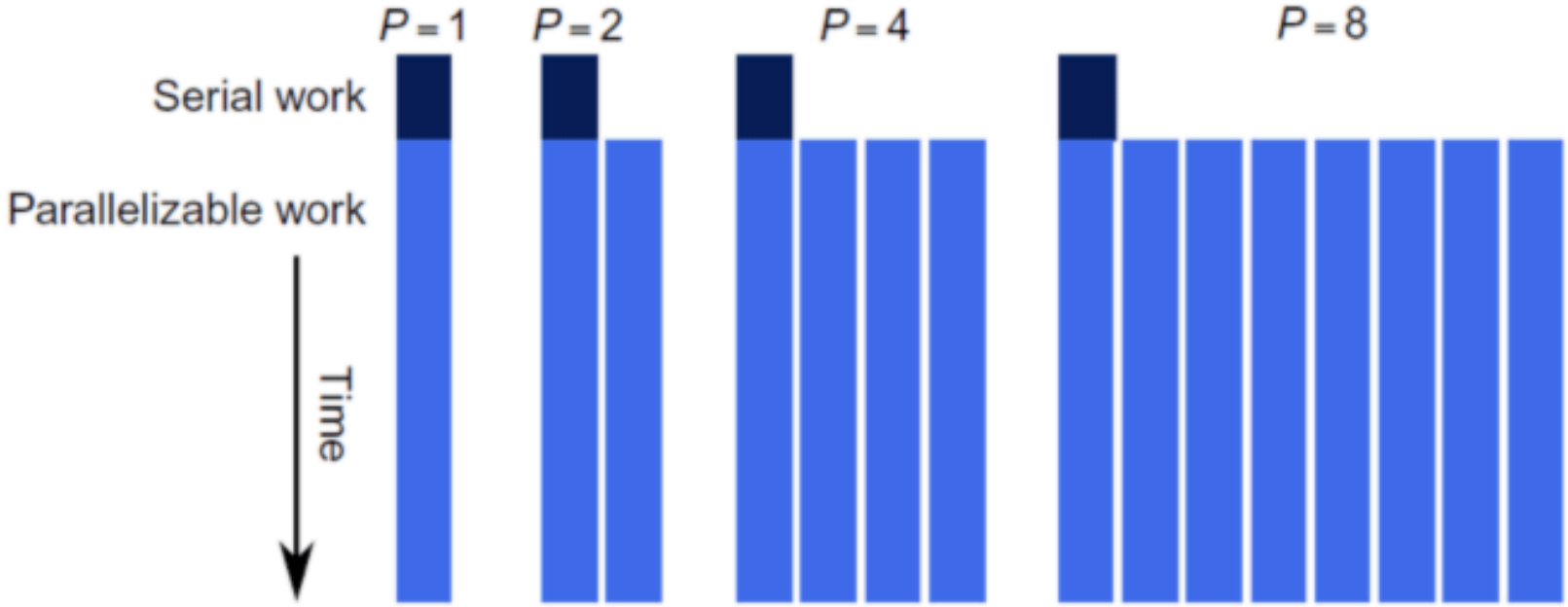
Efficiency


Efficiency for Pi implementation
efficiency
processors
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0
5
10
15
20
25

Another Perspective

- We often use faster computers to solve larger problem instances
- Let's treat time as a constant and allow problem size to increase with number of processors
- "…speedup should be measured by scaling the problem to the number of processors, not by fixing the problem size" – John Gustafson
- Weak scaling
  - Problem size per core stays constant
  - Overall program size increases with number of processors

Gustafson-Barsis's Law



$$SS(N) = \frac{s+p*N}{s+p} = N + (1-N)s$$

http://www.drdobbs.com/parallel/amdahls-law-vs-gustafson-barsis-law/240162980?pgno=2

Timing your code

- Use the unix time command
- Provides time for
  - Real – wall-clock time
  - User
  - Sys

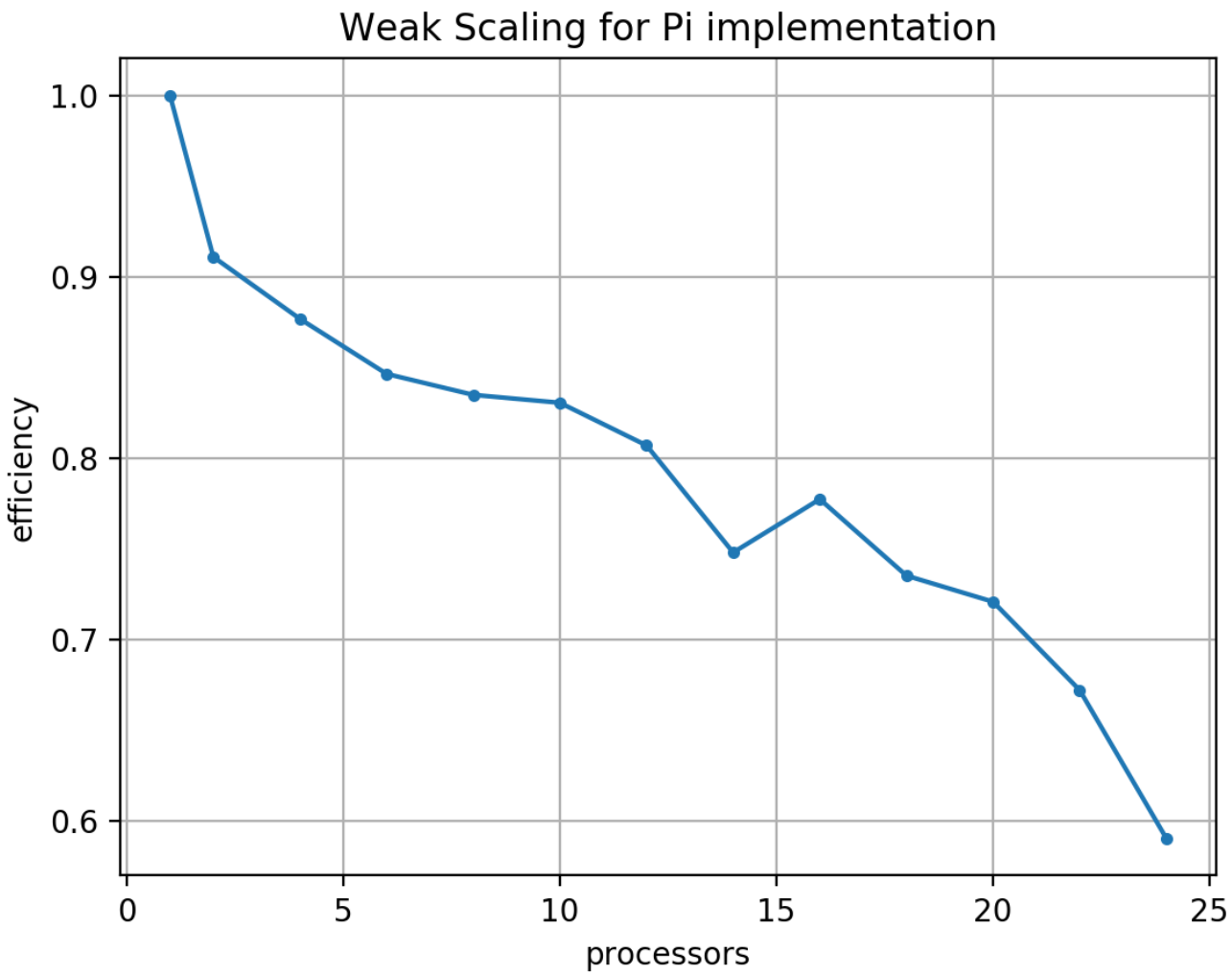
- Use real time / wall-clock time for parallel benchmarking
- User + Sys gives you CPU time
  - Can be larger then real time – multithreading

- Use tools within your language
  - Module timeit for python

Example Weak Scaling

- Run the following job scripts on Summit
  - 04-serial.sh
    - Creates timing for the serial time of the program
  - 04-weak_scaling
    - Creates timing for weak scaling

Weak Scaling



Memory usage

- Massif as part of valgrind
- Valgrind help with memory related issues
  - `$ module load valgrind`
  - `$ valgrind --tool=massif python3 pi_serial.py 1000000`
  - `$ ms_print massif.out.88892`

Massif Memory Usage Report

Questions?

- Email rc-help@colorado.edu
- Twitter: CUBoulderRC

- Link to survey on this topic:

http://tinyurl.com/curc-survey16

- Slides: https://github.com/ResearchComputing/Parallelization_Workshop/tree/master/Day1