CSE 633: Parallel Algorithms

Fall 2012

Parallelized Hash Collision Attacking

Benedikt Budig

Course Instructor:
Russ Miller

The Topic in a Nutshell

image source: shutterstock

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Reason to do that?

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We focus on

$\longrightarrow$ MD5

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Parallel Approach

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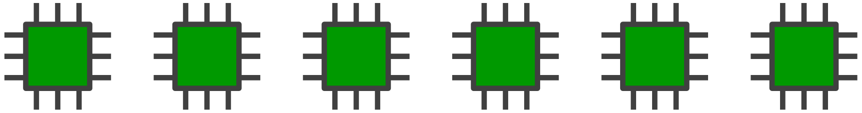

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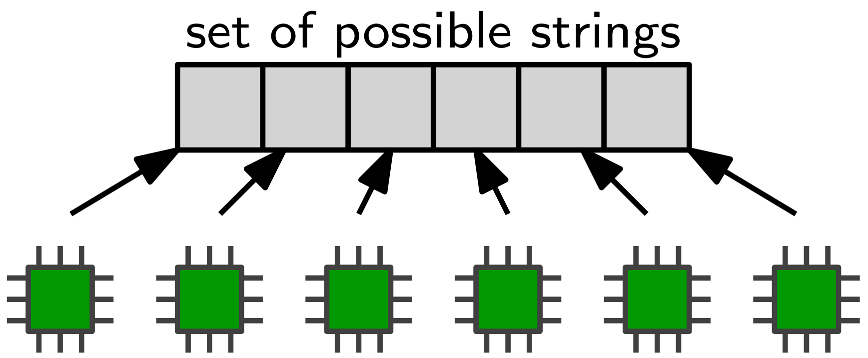

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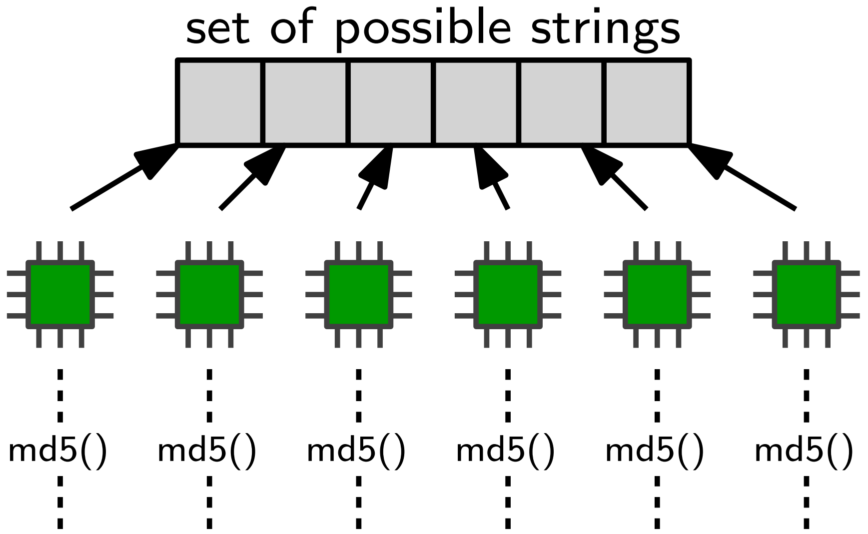

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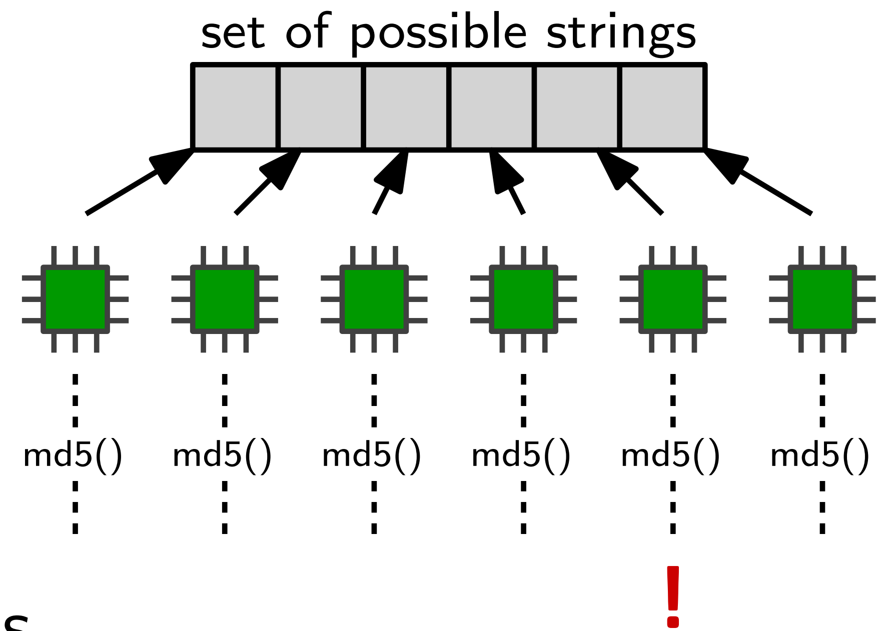

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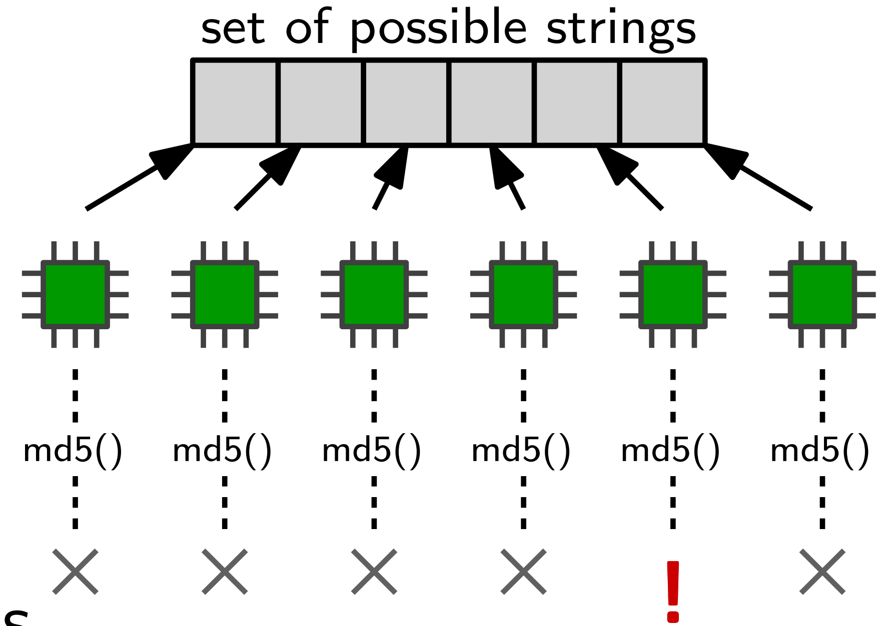

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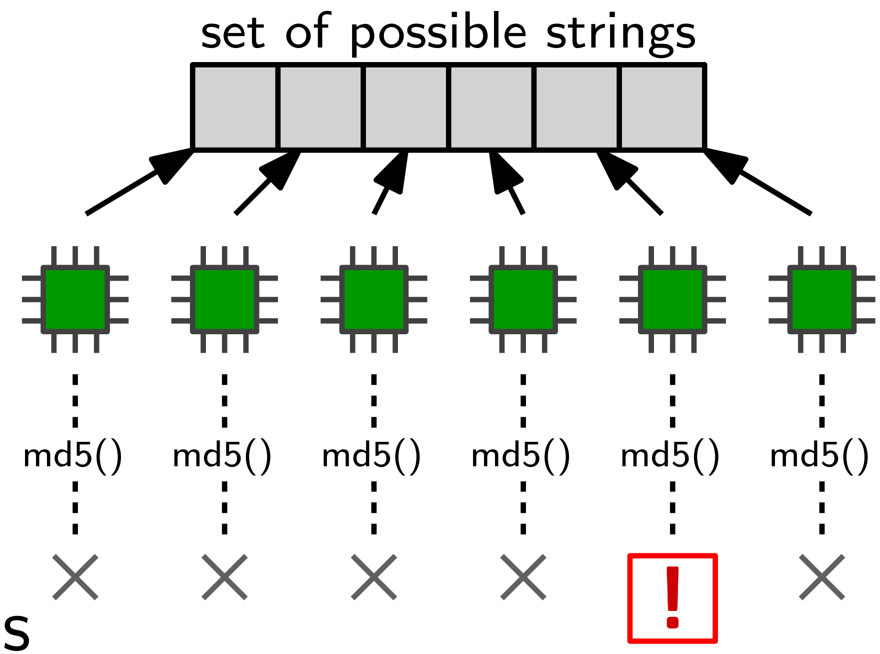

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4. return the colliding string

Technical Realization

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Hardware

image source: CCR website

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Hardware

- use of CPUs

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- use of CPUs
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- implementation using the C++ programming language

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Future Work

- tweaks for MPI and OpenMPI

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- tweaks for MPI and OpenMPI
- implementation using CUDA

Benchmarks

image source: autoanything

Benchmarks

First Test: OpenMP on 12 Core System

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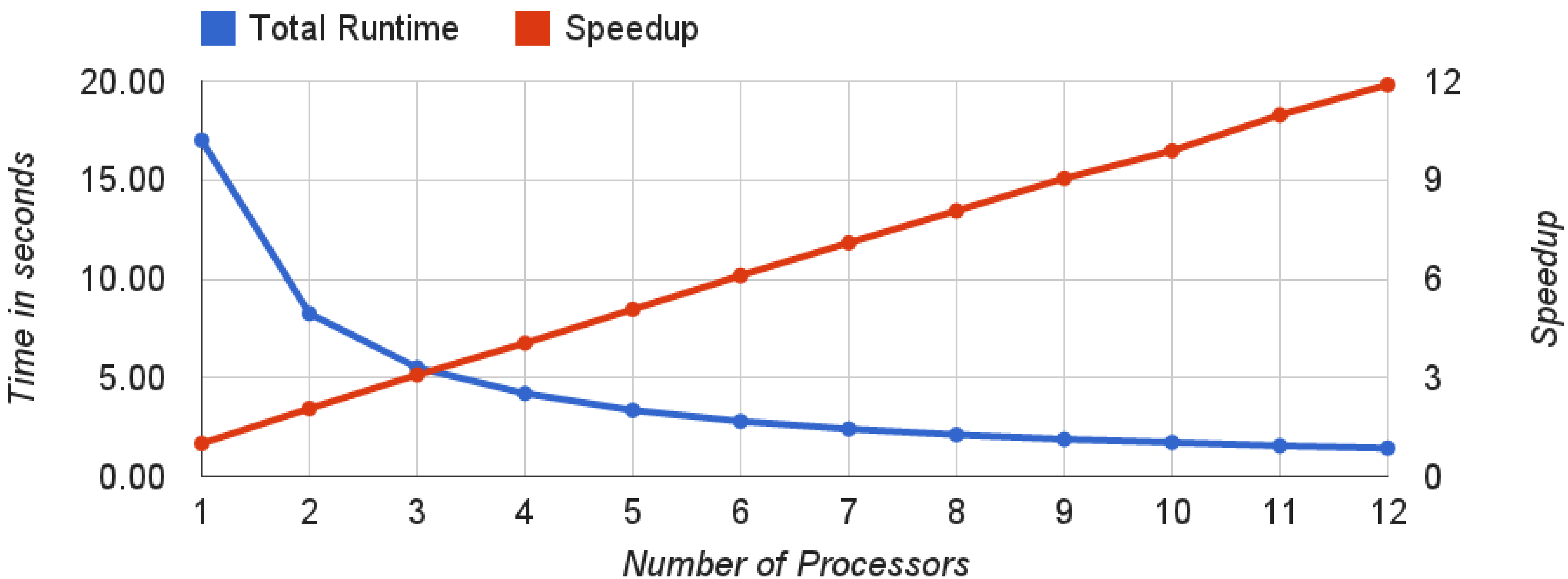

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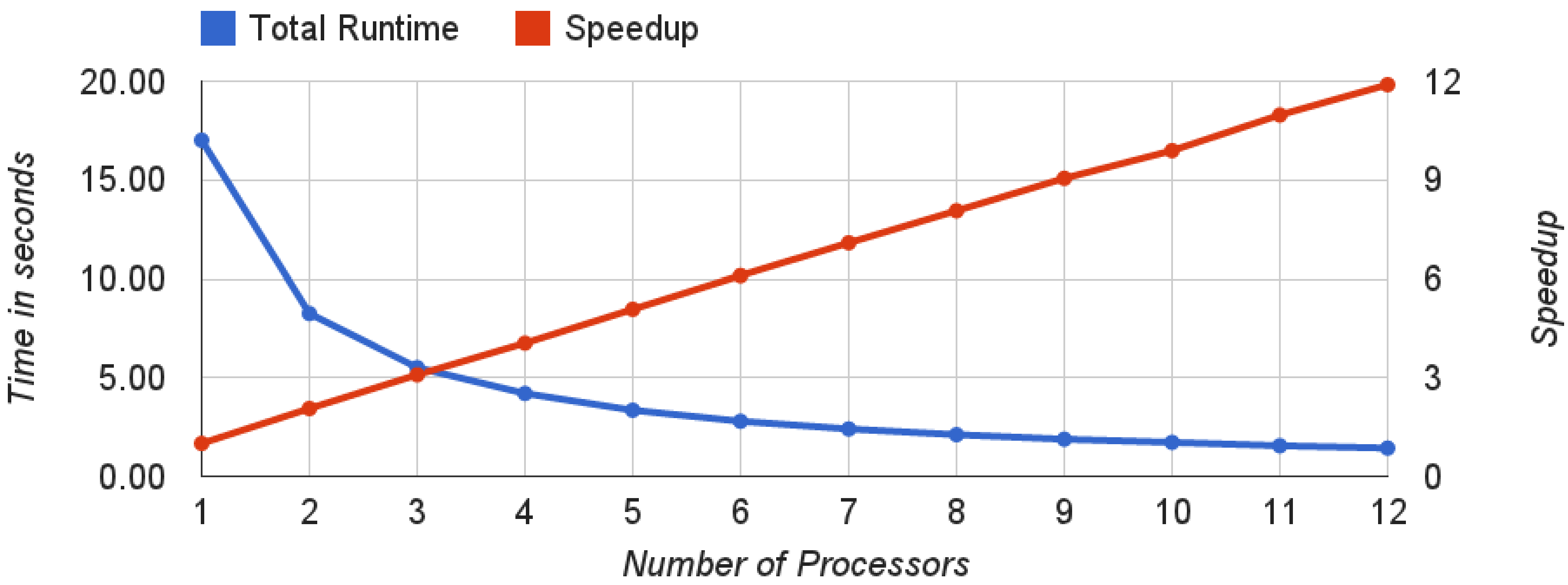

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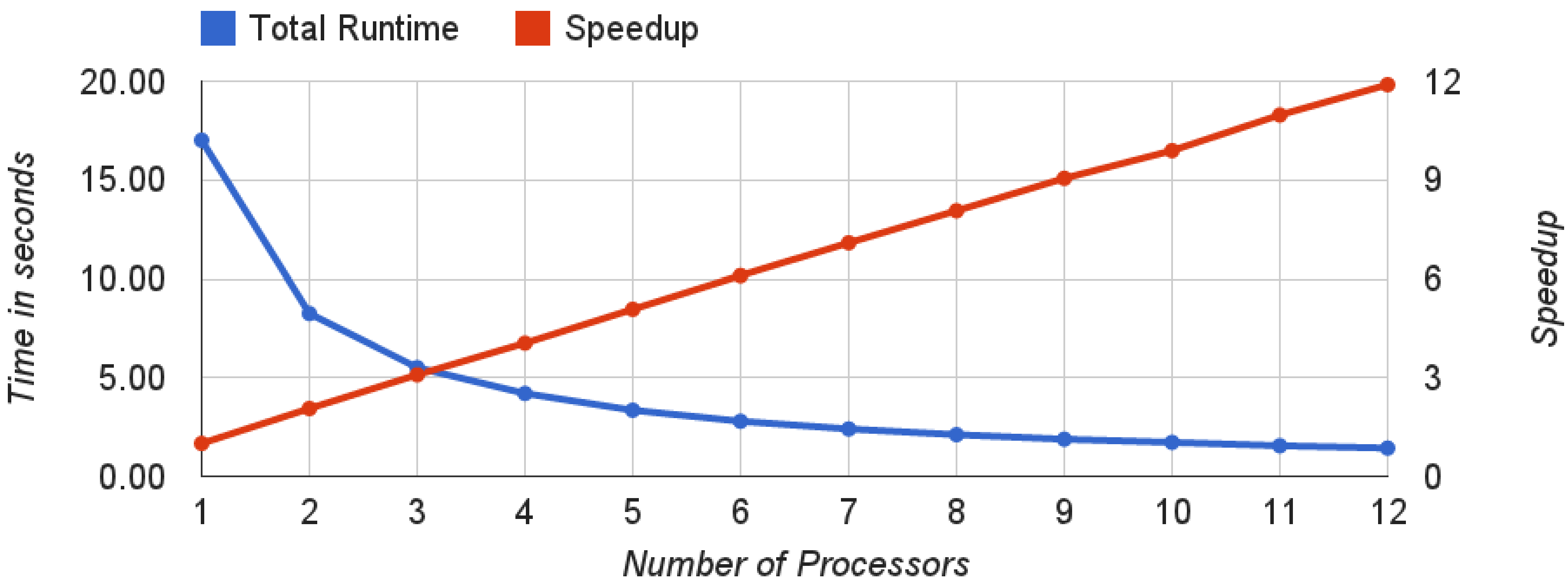

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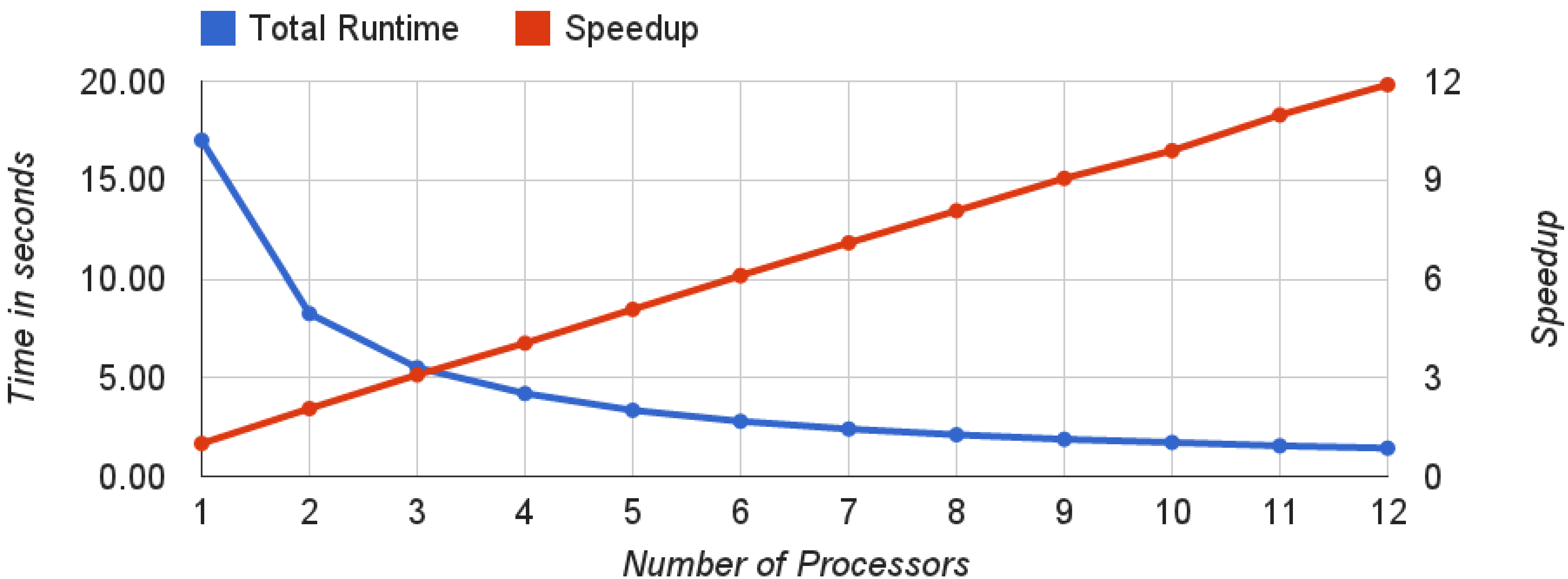

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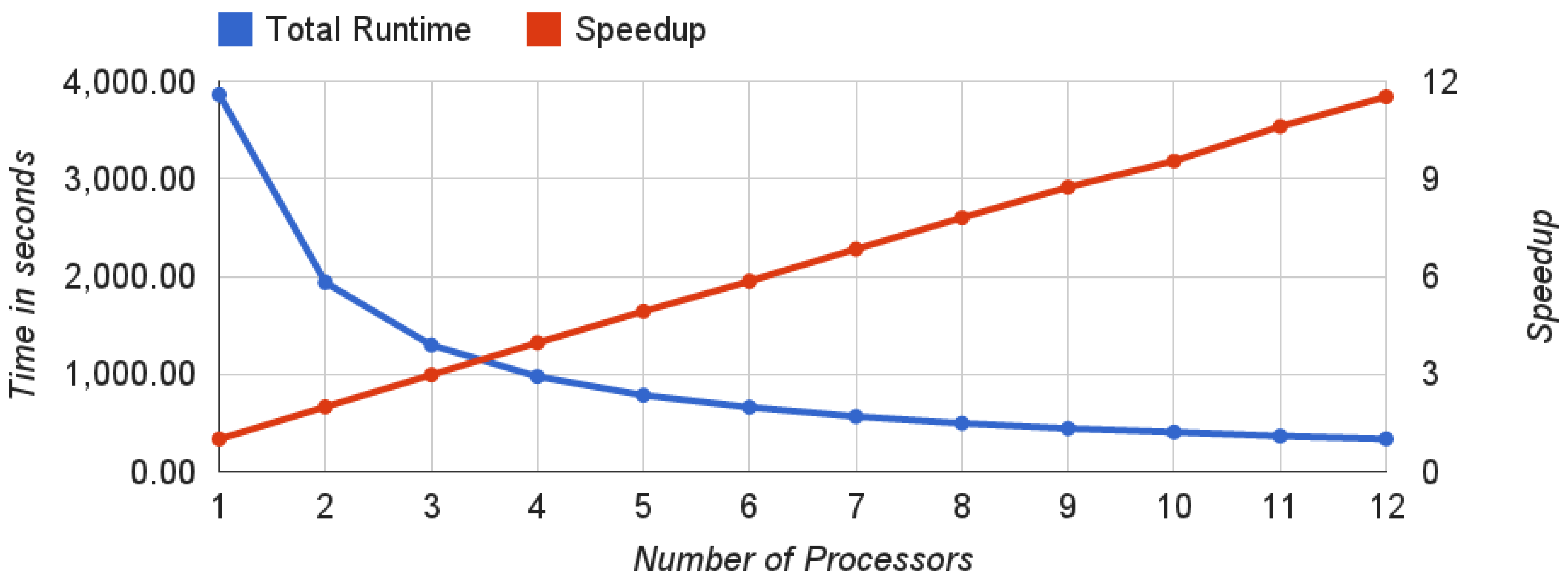

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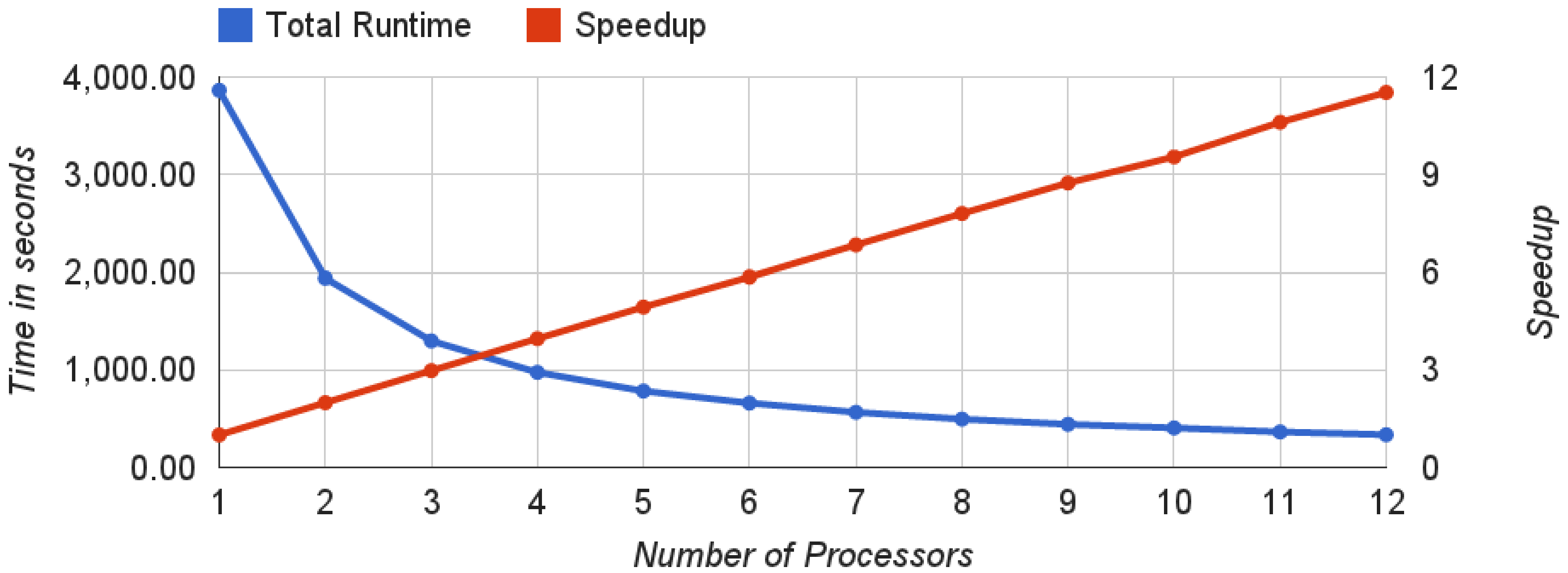

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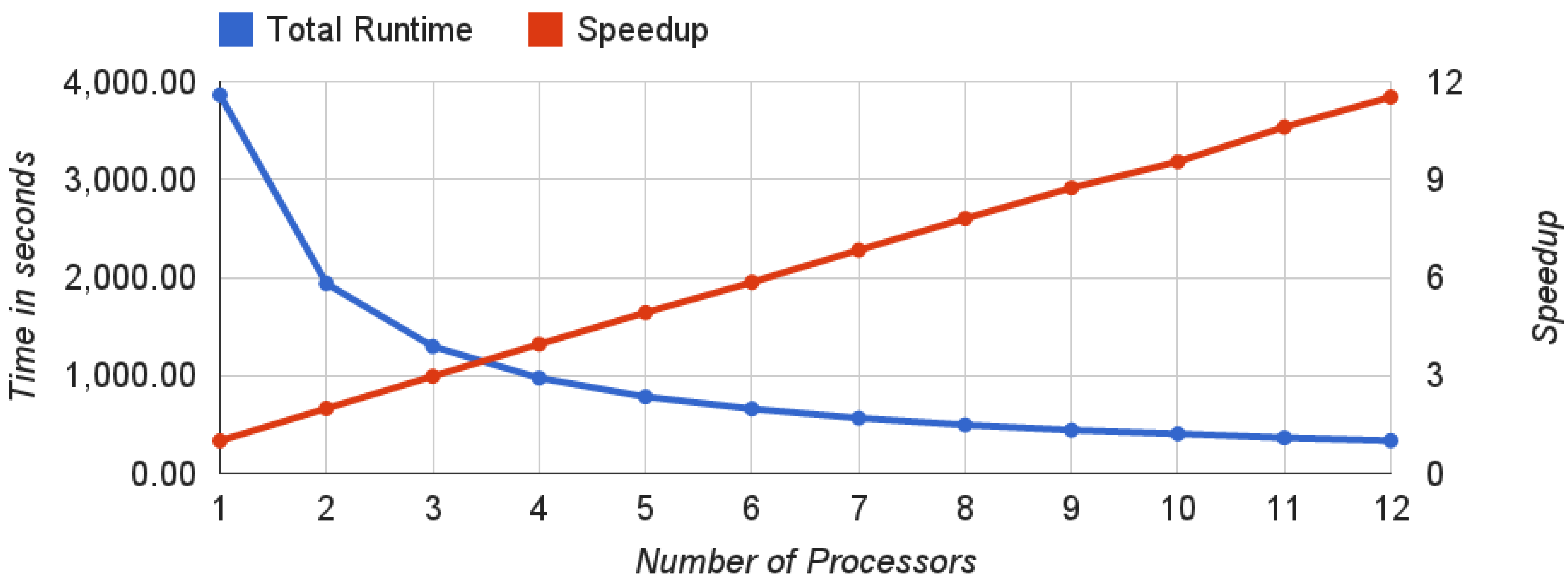

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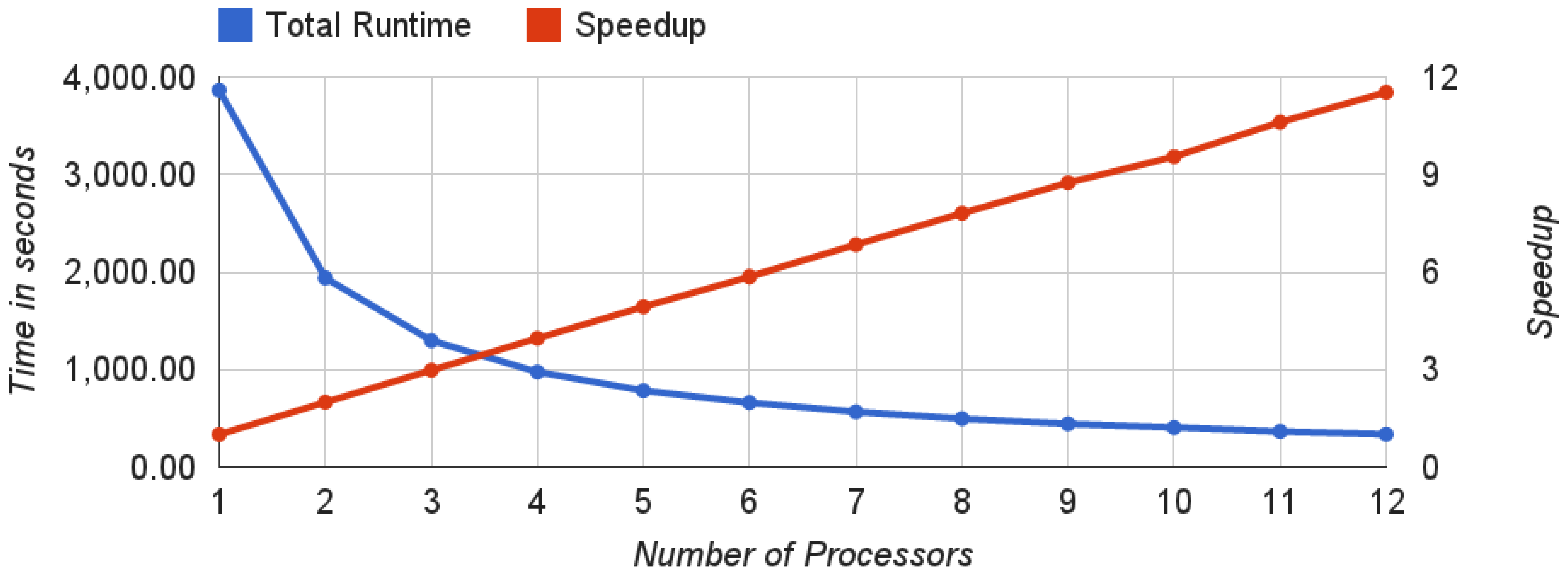

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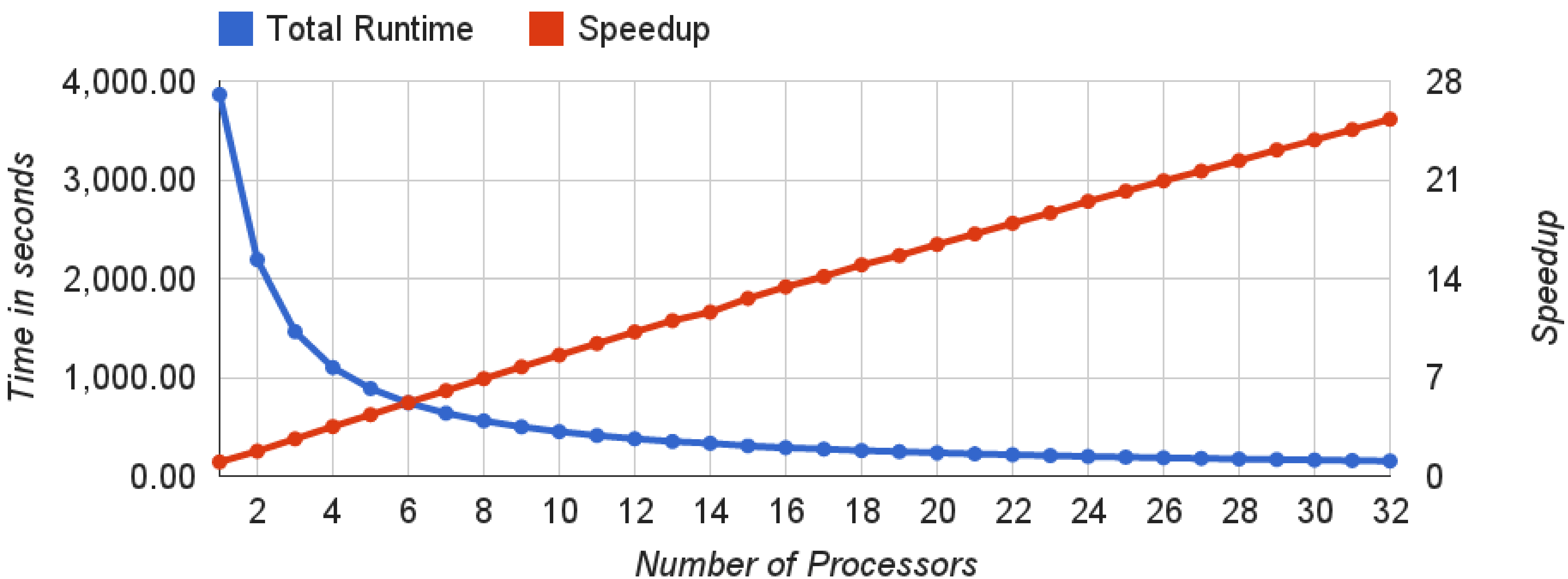

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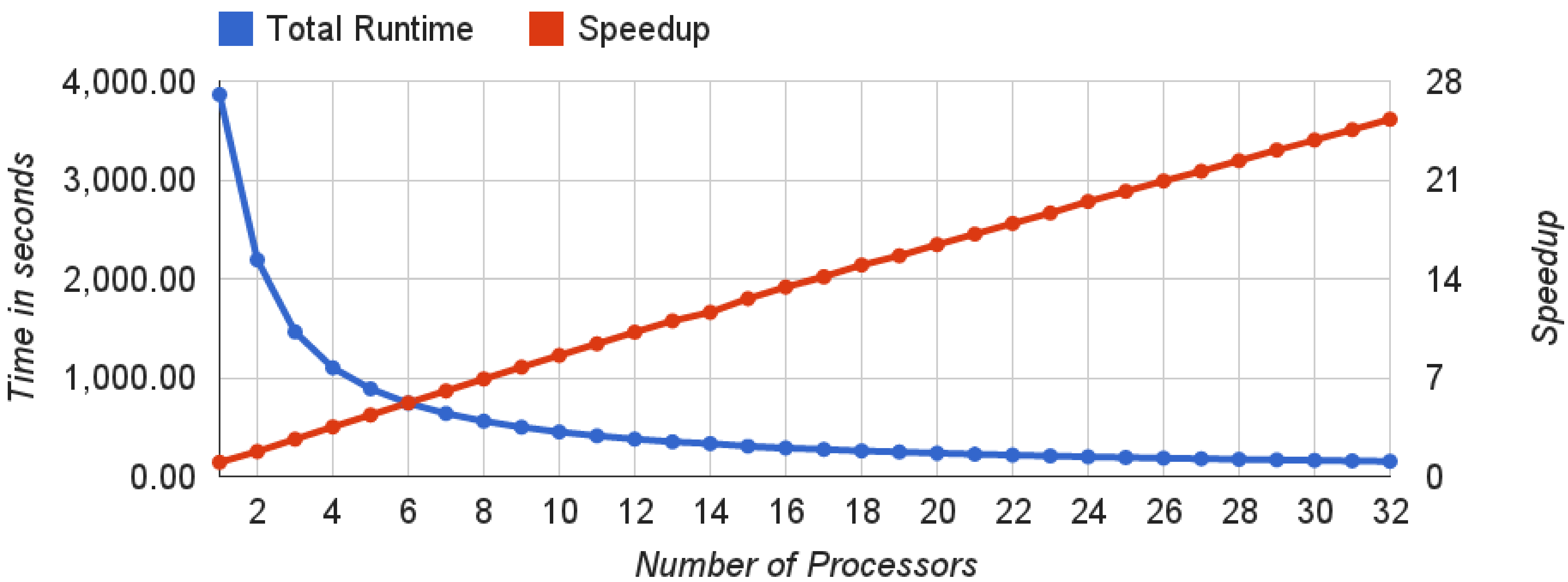

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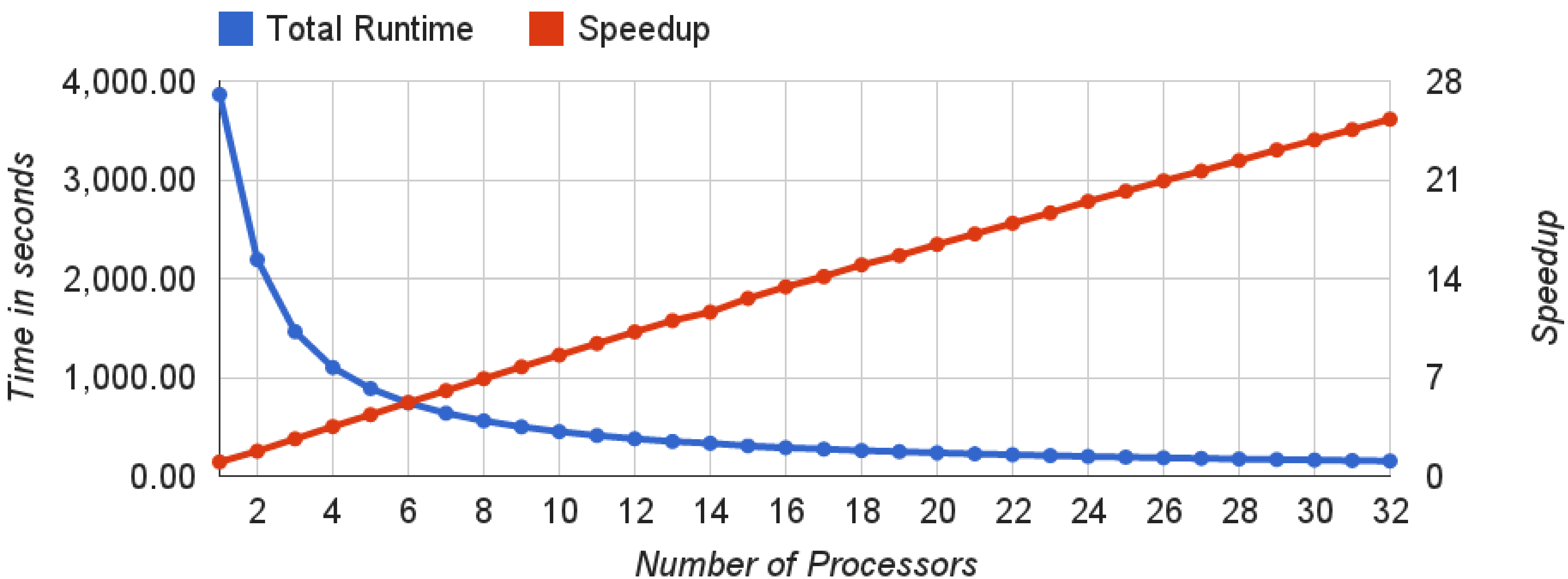

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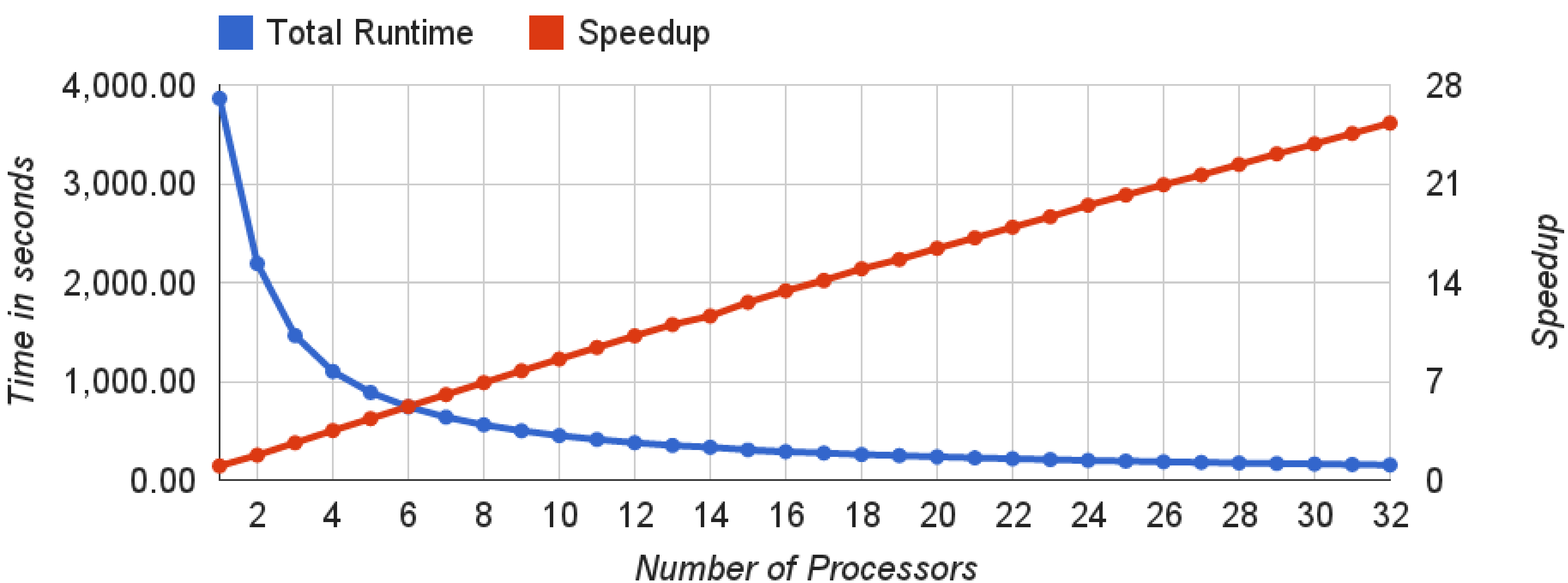

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Fourth Test: MPI on $6 \cdot 12$ Core Systems

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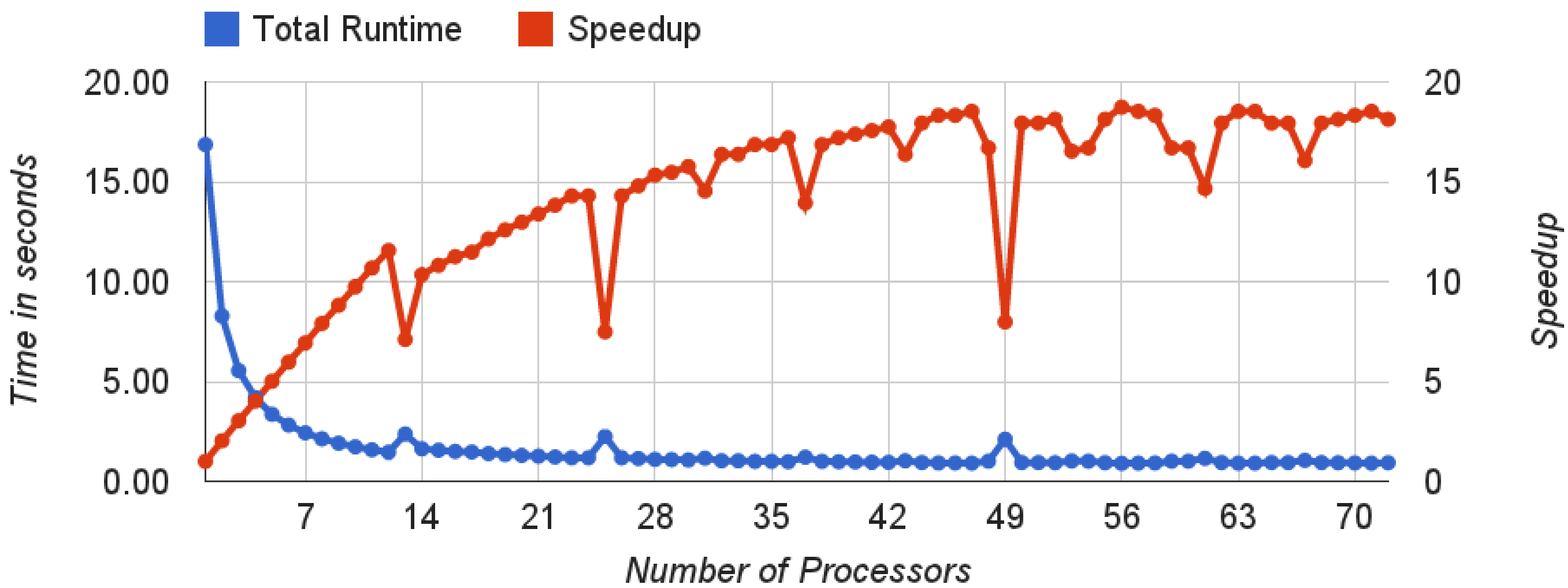

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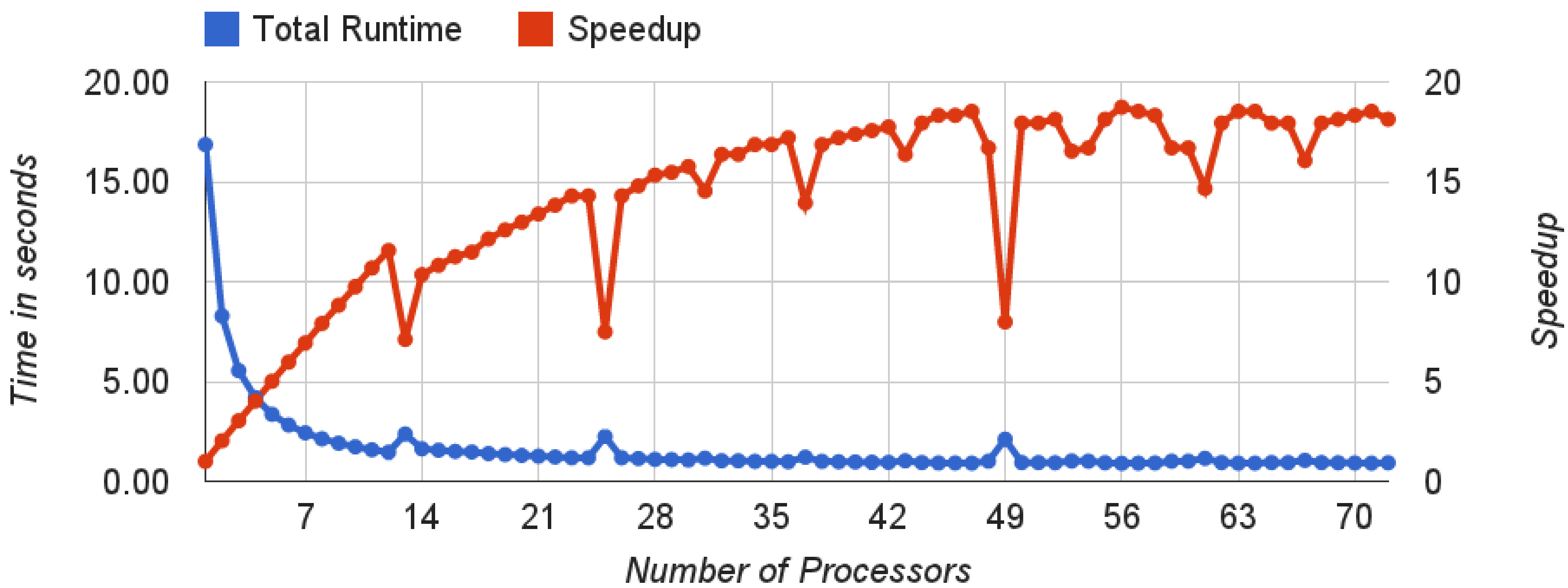

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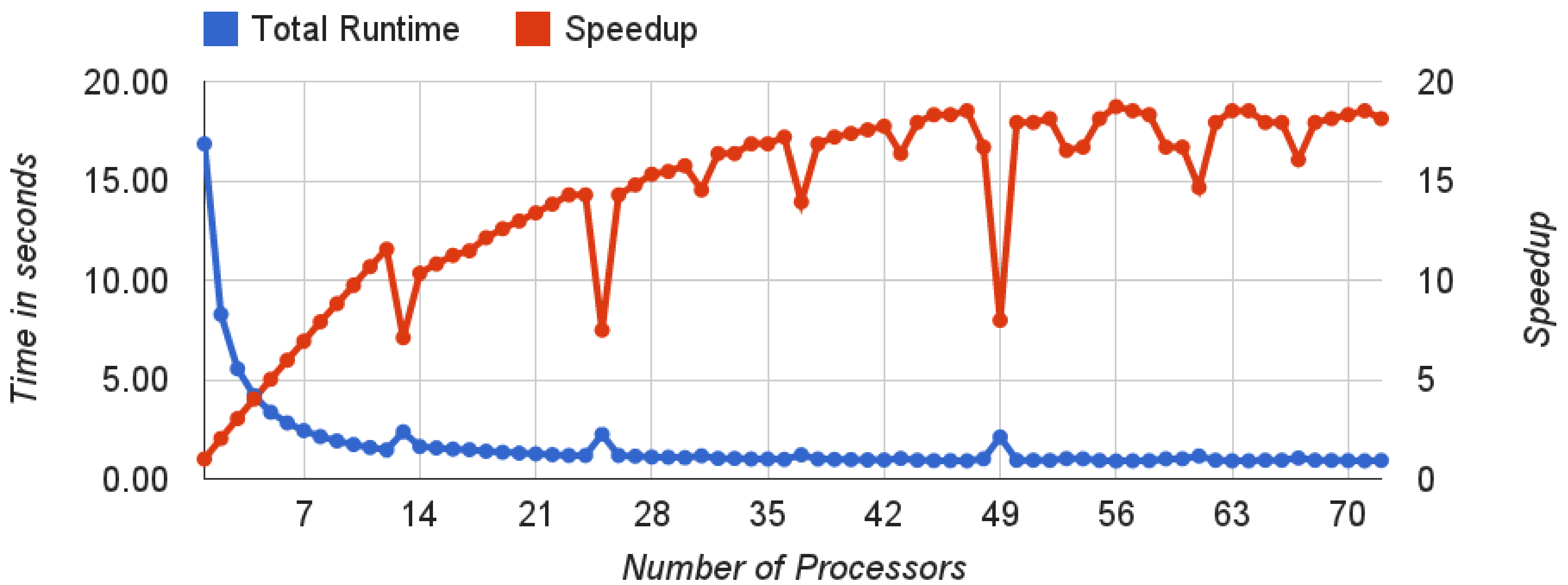

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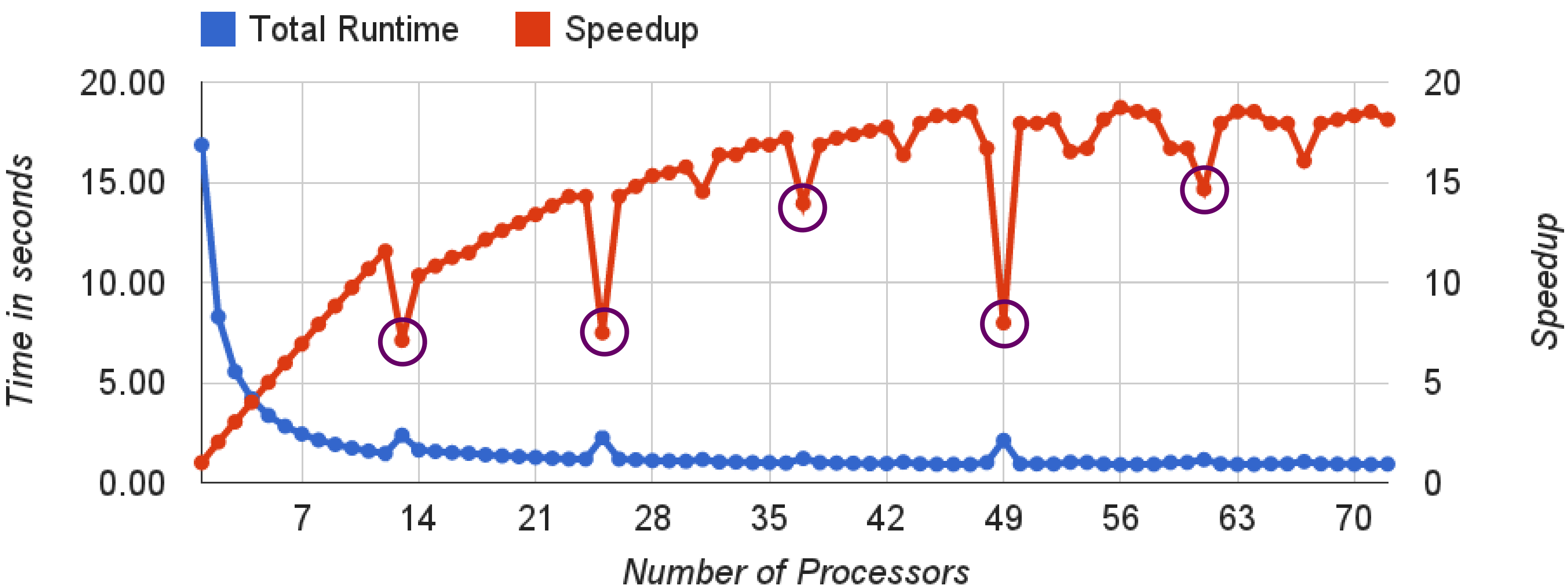

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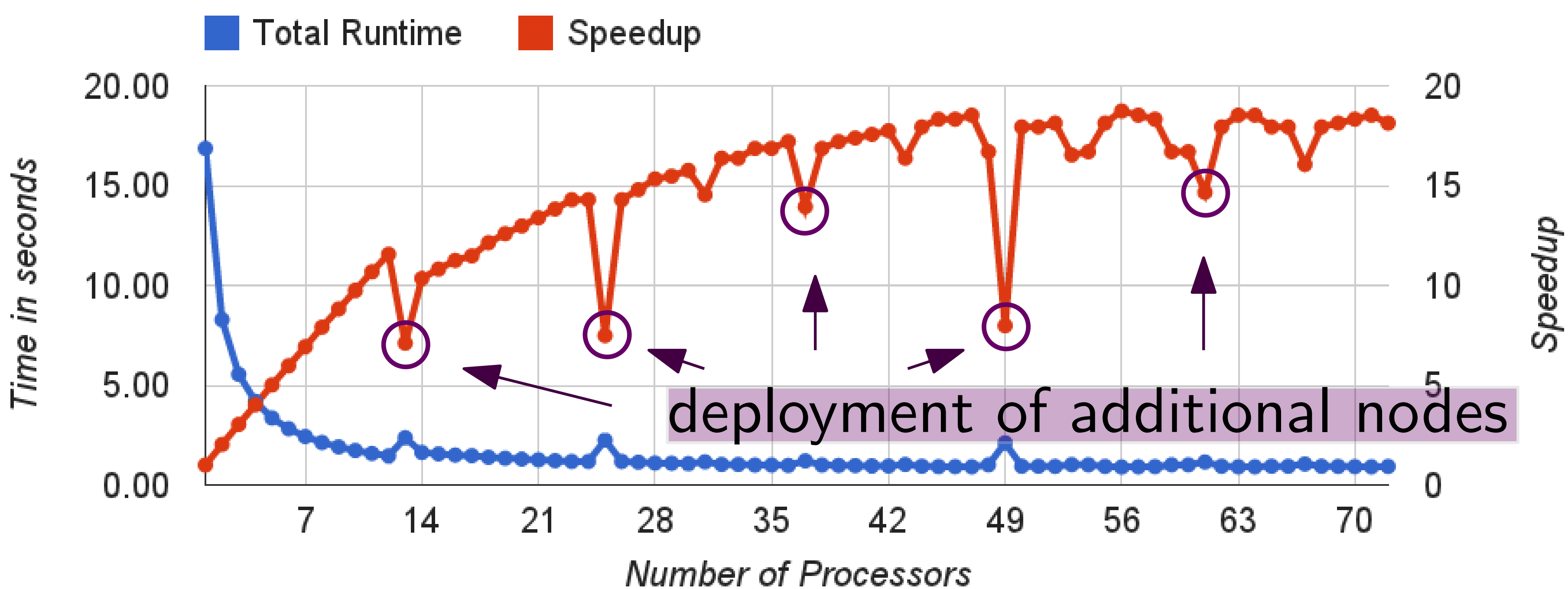

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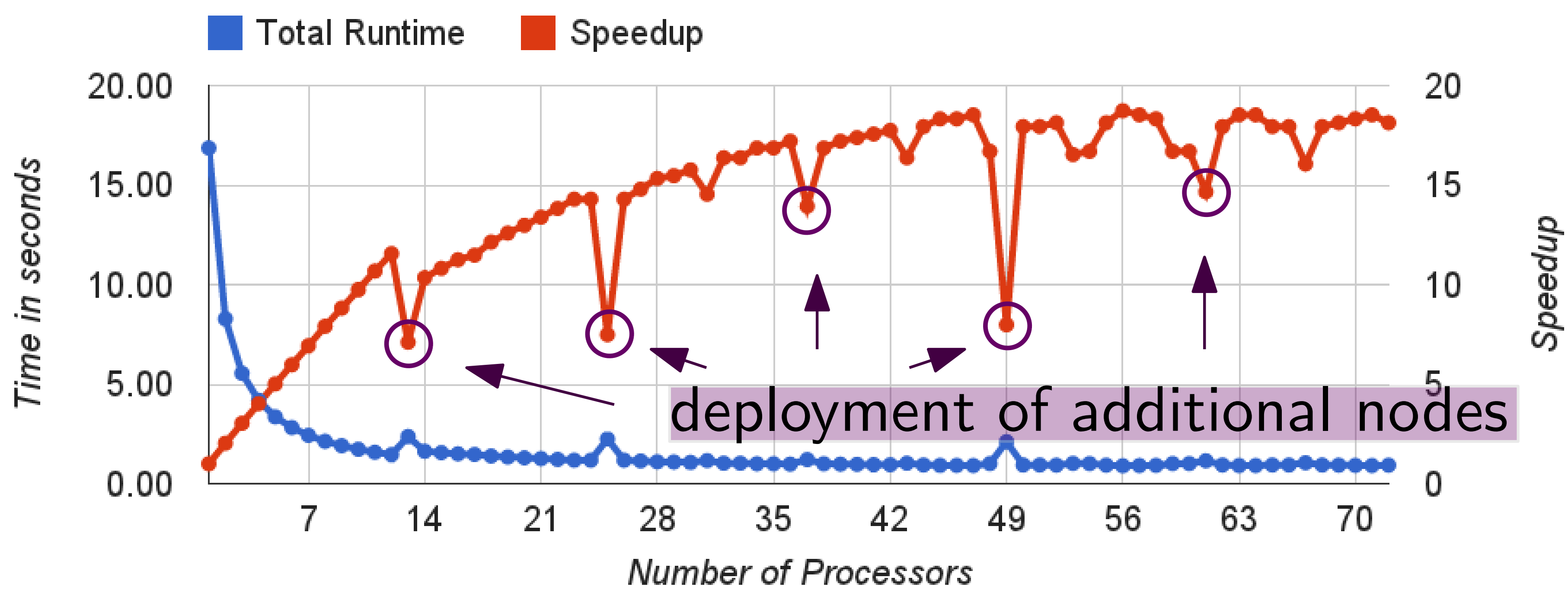

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→ speed drop due to
- small problem size
- setup overhead

image source: autoanything

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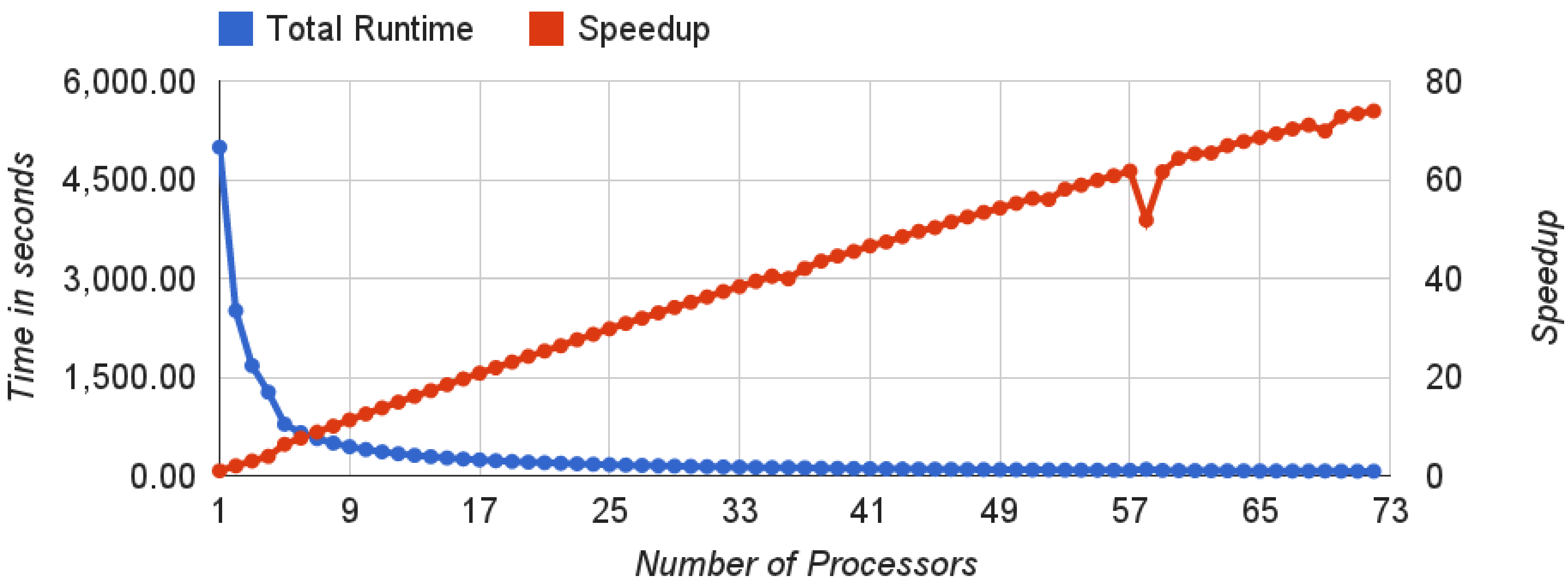

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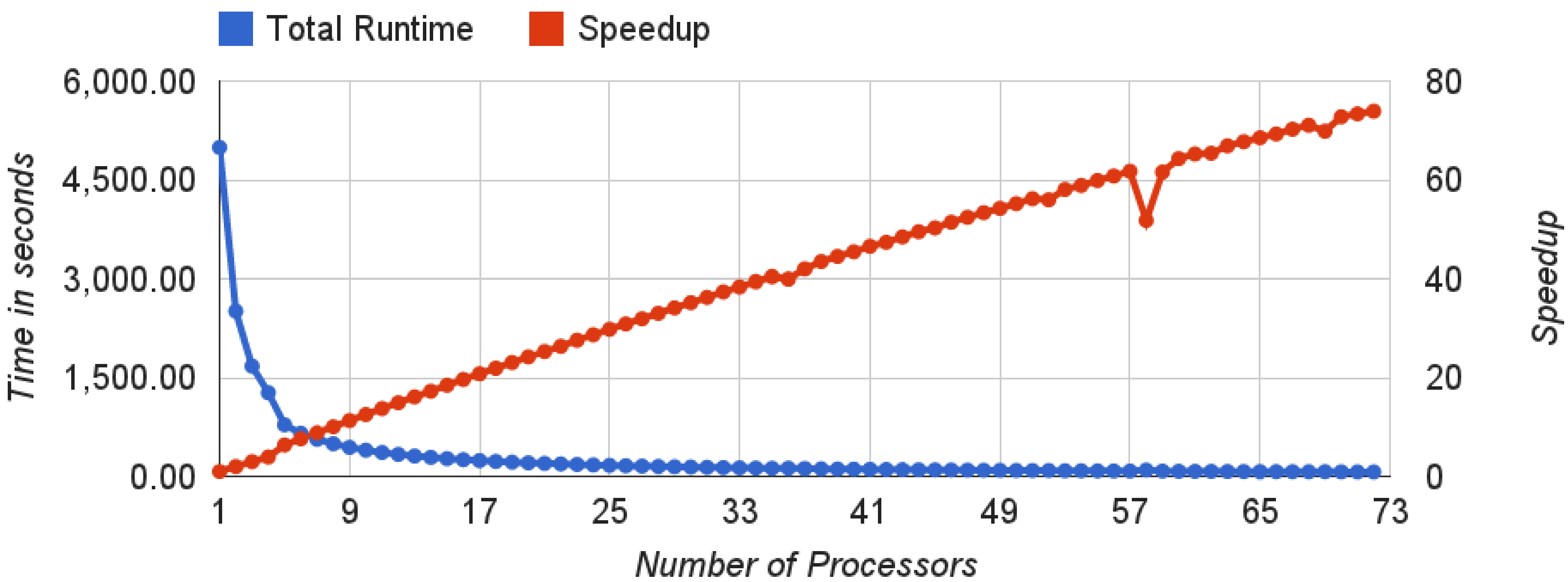

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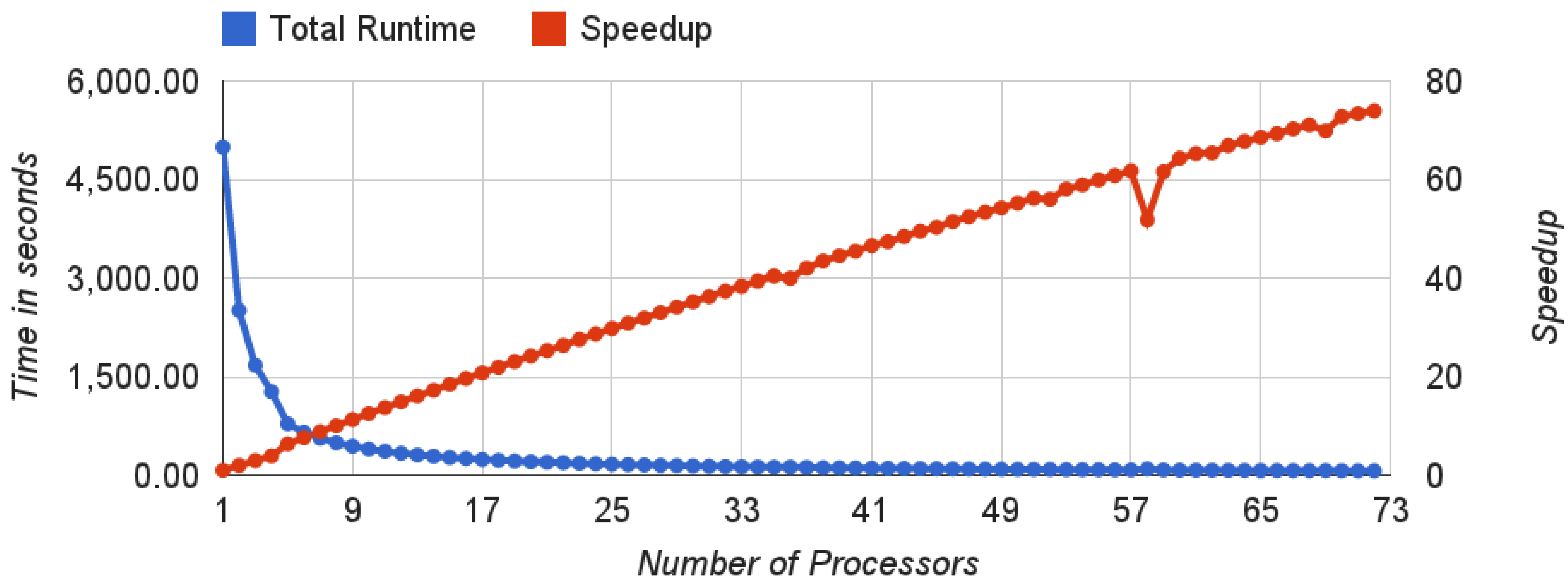
Fifth Test: MPI on $6 \cdot 12$ Core Systems

- 6 hosts with 12 Intel Xeon E5645 at 2.40GHz
- input: md5(x) with $x \in \{0,1\}^{32}$



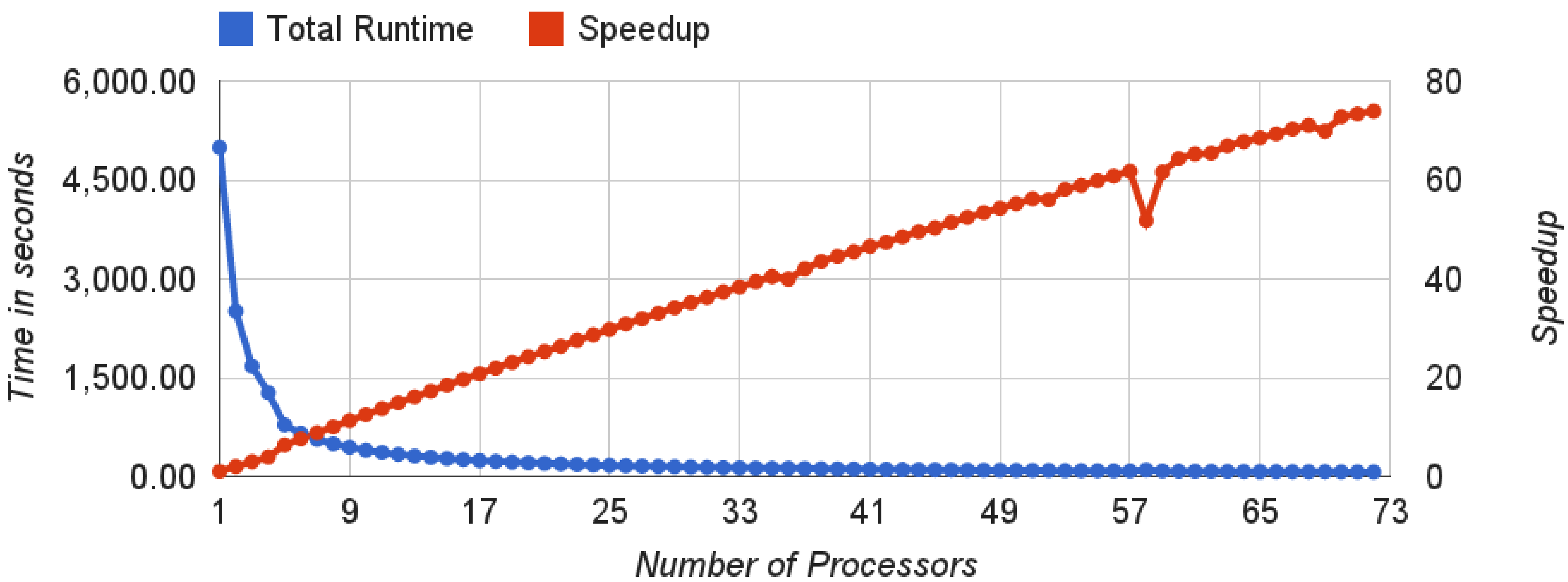
- 67.54 seconds to find collision
- approx. 1 billion strings tried

image source: autoanything

Benchmarks

Fifth Test: MPI on $6 \cdot 12$ Core Systems

- 6 hosts with 12 Intel Xeon E5645 at 2.40GHz
- input: md5(x) with $x \in \{0,1\}^{32}$



- 67.54 seconds to find collision
- approx. 1 billion strings tried

$\longrightarrow$ linear speedup

image source: autoanything

Benchmarks

image source: autoanything

Benchmarks

Sixth Test: MPI on $2 \cdot 32$ Core Systems

image source: autoanything

Benchmarks

Sixth Test: MPI on 2 · 32 Core Systems

image source: autoanything

Benchmarks

Sixth Test: MPI on 2 · 32 Core Systems

- 2 hosts with 32 Xeon E7-4830 at 2.13GHz

image source: autoanything

Benchmarks

Sixth Test: MPI on $2 \cdot 32$ Core Systems

- 2 hosts with 32 Xeon E7-4830 at 2.13GHz
- input: md5(x) with $x \in \{0, 1\}^{24}$

image source: autoanything

Benchmarks

Sixth Test: MPI on $2 \cdot 32$ Core Systems

- 2 hosts with 32 Xeon E7-4830 at 2.13GHz
- input: md5(x) with $x \in \{0,1\}^{24}$

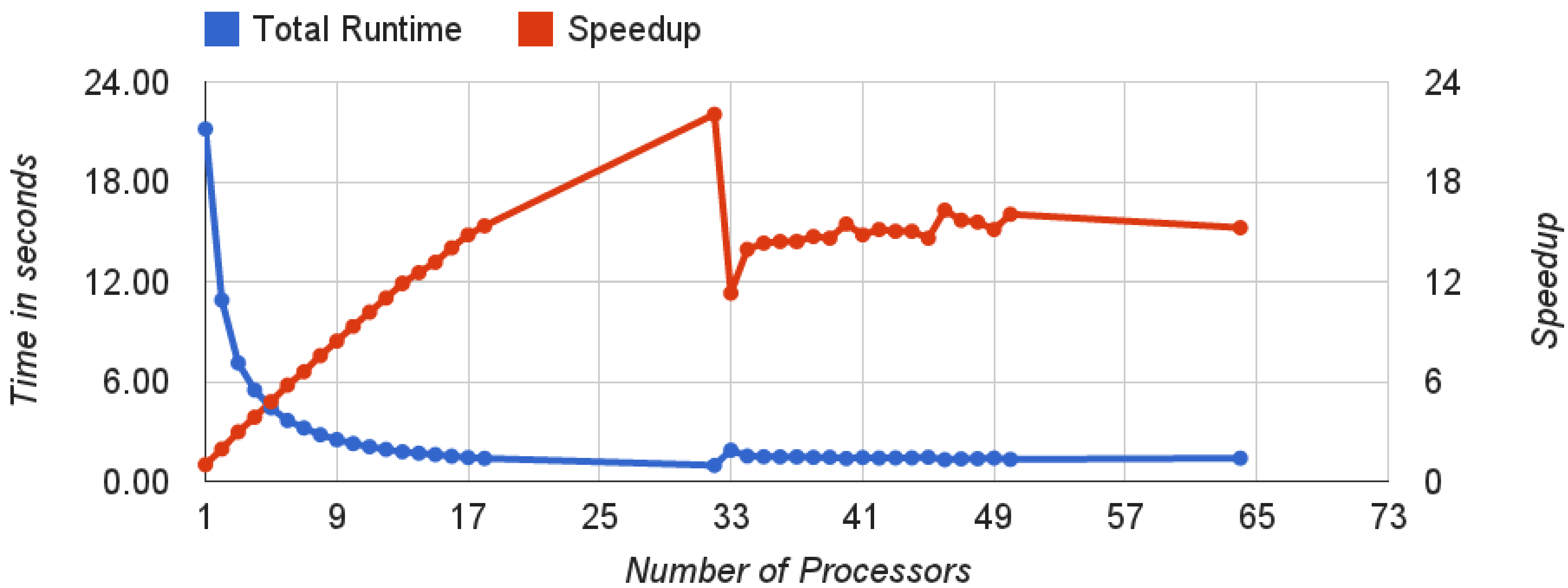
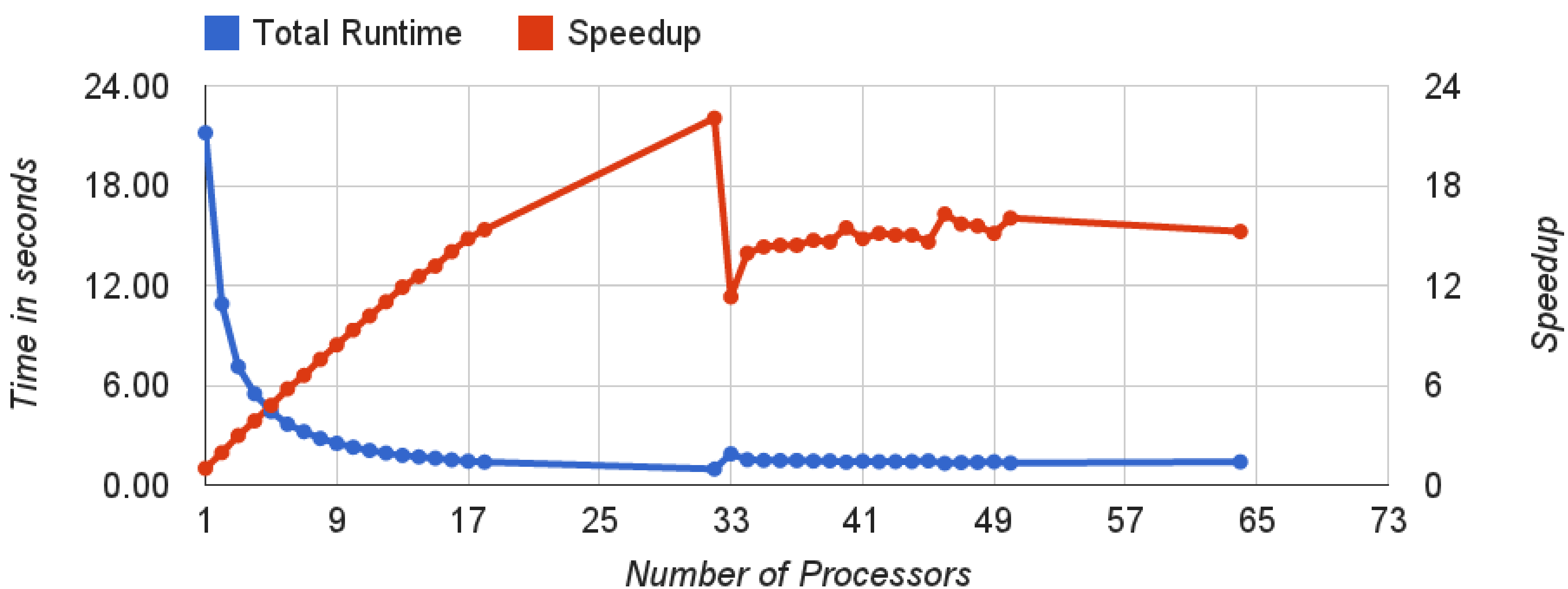


image source: autoanything

Benchmarks

Sixth Test: MPI on $2 \cdot 32$ Core Systems

- 2 hosts with 32 Xeon E7-4830 at 2.13GHz
- input: md5(x) with $x \in \{0,1\}^{24}$



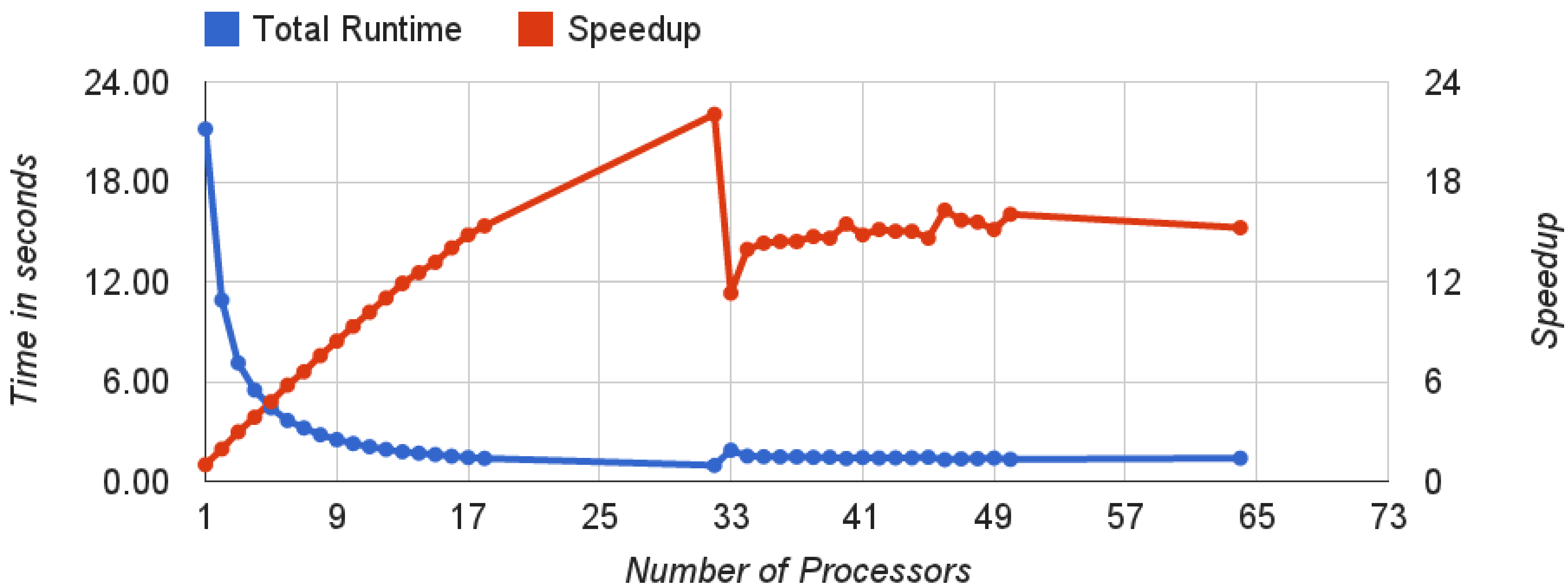
- 0.96 seconds to find collision

image source: autoanything

Benchmarks

Sixth Test: MPI on $2 \cdot 32$ Core Systems

- 2 hosts with 32 Xeon E7-4830 at 2.13GHz
- input: md5(x) with $x \in \{0, 1\}^{24}$



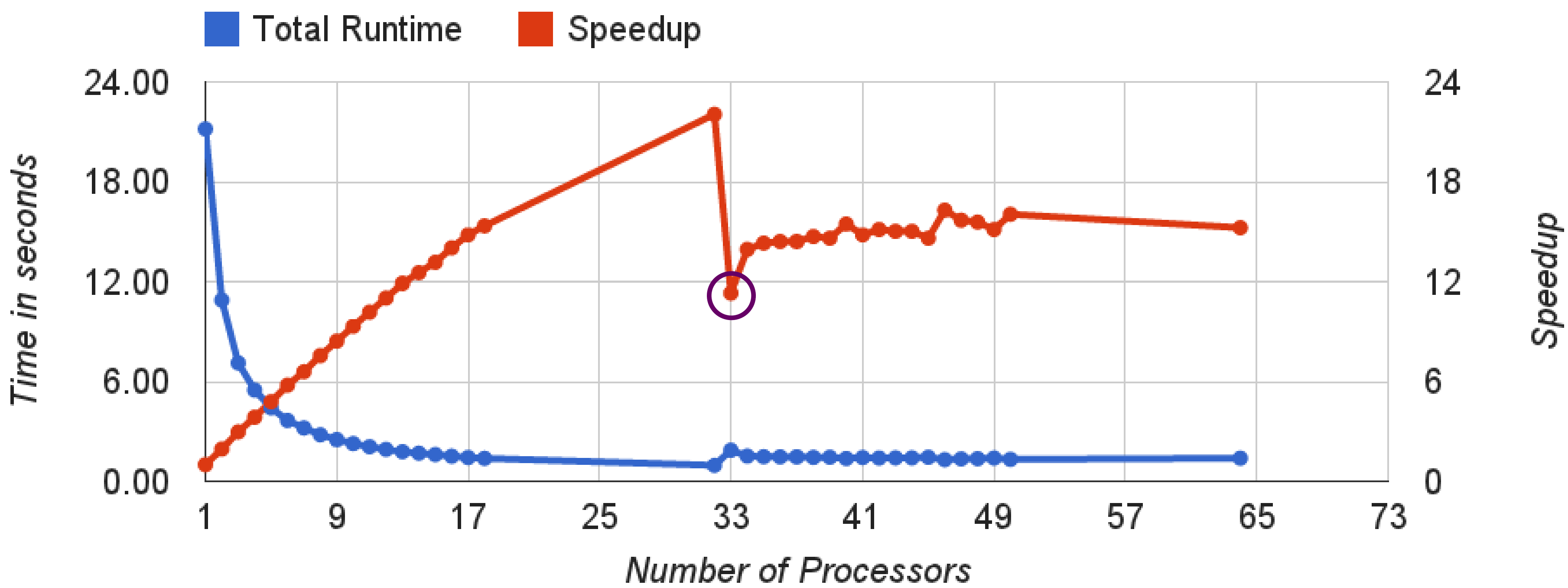
- 0.96 seconds to find collision
- approx. 4 million strings tried

image source: autoanything

Benchmarks

Sixth Test: MPI on 2 · 32 Core Systems

- 2 hosts with 32 Xeon E7-4830 at 2.13GHz
- input: md5(x) with $x \in \{0,1\}^{24}$



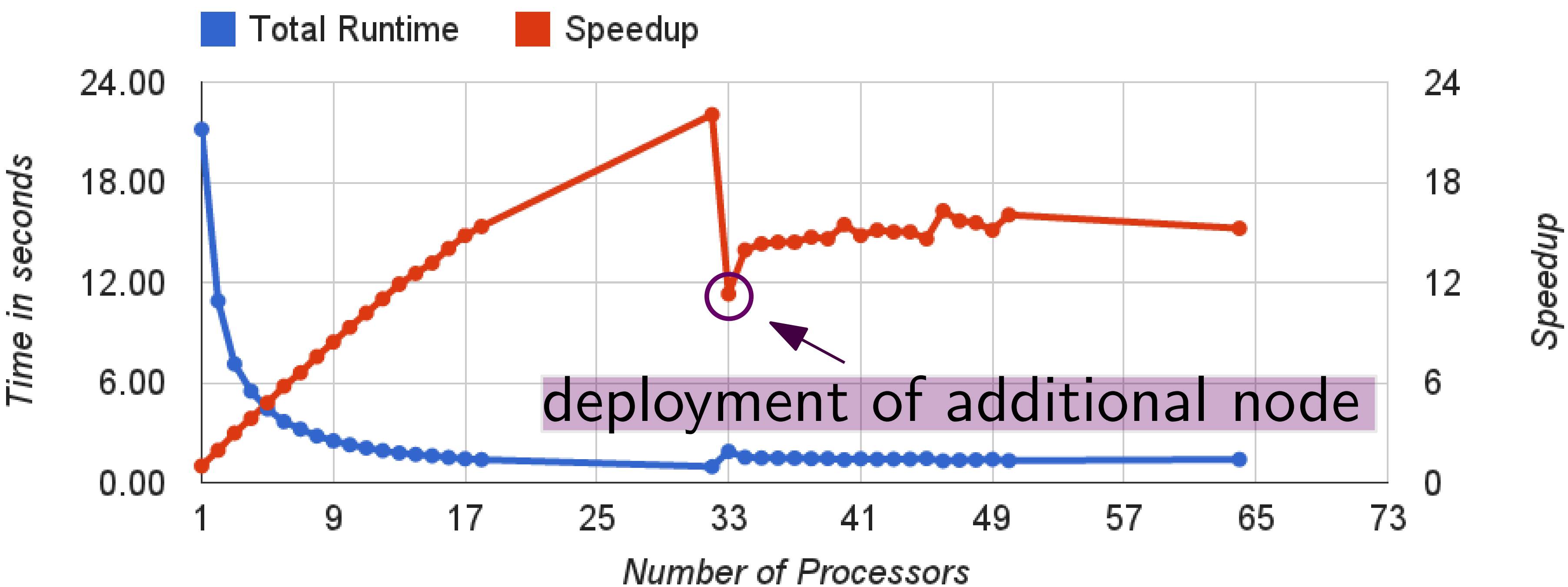
- 0.96 seconds to find collision → speed drop
- approx. 4 million strings tried

image source: autoanything

Benchmarks

Sixth Test: MPI on $2 \cdot 32$ Core Systems

- 2 hosts with 32 Xeon E7-4830 at 2.13GHz
- input: md5(x) with $x \in \{0,1\}^{24}$



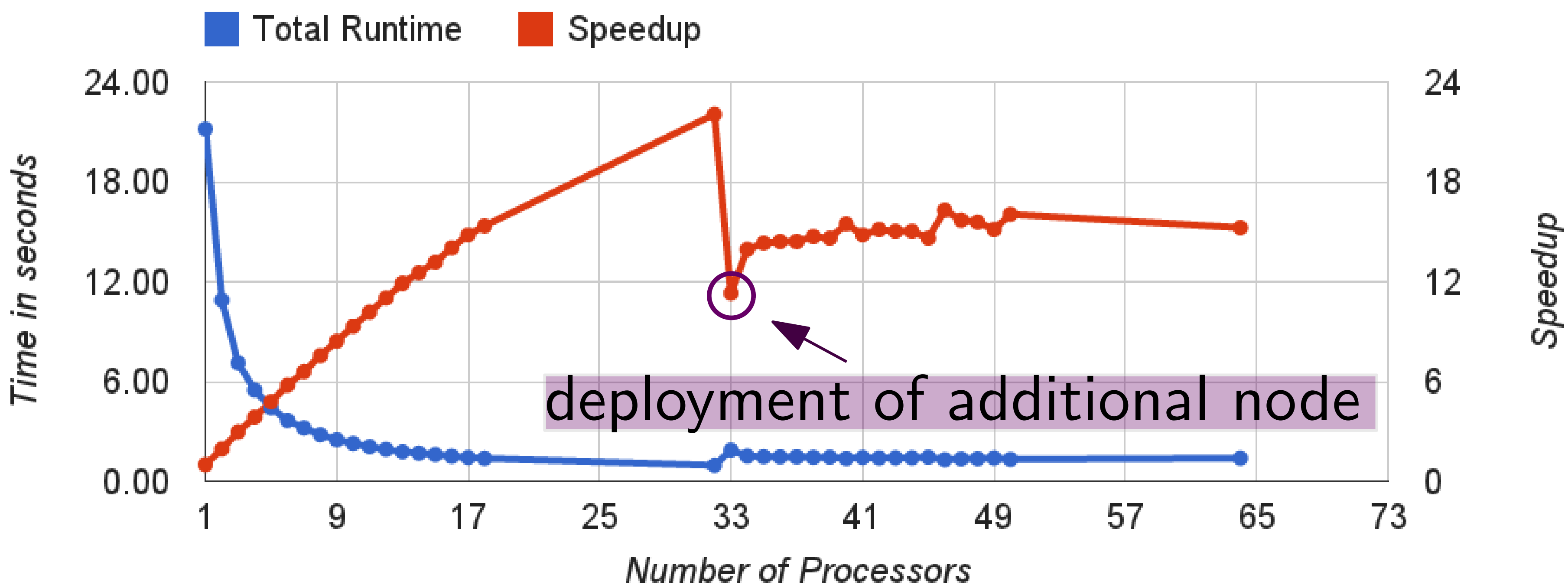
- 0.96 seconds to find collision → speed drop due to
- approx. 4 million strings tried

image source: autoanything

Benchmarks

Sixth Test: MPI on $2 \cdot 32$ Core Systems

- 2 hosts with 32 Xeon E7-4830 at 2.13GHz
- input: md5(x) with $x \in \{0,1\}^{24}$



- 0.96 seconds to find collision
- approx. 4 million strings tried

→ speed drop due to

- small problem size
- setup overhead

image source: autoanything

Benchmarks

image source: autoanything

Benchmarks

Seventh Test: MPI on $2 \cdot 32$ Core Systems

image source: autoanything

Benchmarks

Seventh Test: MPI on $2 \cdot 32$ Core Systems

- 2 hosts with 32 Xeon E7-4830 at 2.13GHz

image source: autoanything

Benchmarks

Seventh Test: MPI on $2 \cdot 32$ Core Systems

- 2 hosts with 32 Xeon E7-4830 at 2.13GHz
- input: md5(x) with $x \in \{0, 1\}^{32}$

image source: autoanything

Benchmarks

Seventh Test: MPI on $2 \cdot 32$ Core Systems

- 2 hosts with 32 Xeon E7-4830 at 2.13GHz
- input: md5(x) with $x \in \{0,1\}^{32}$

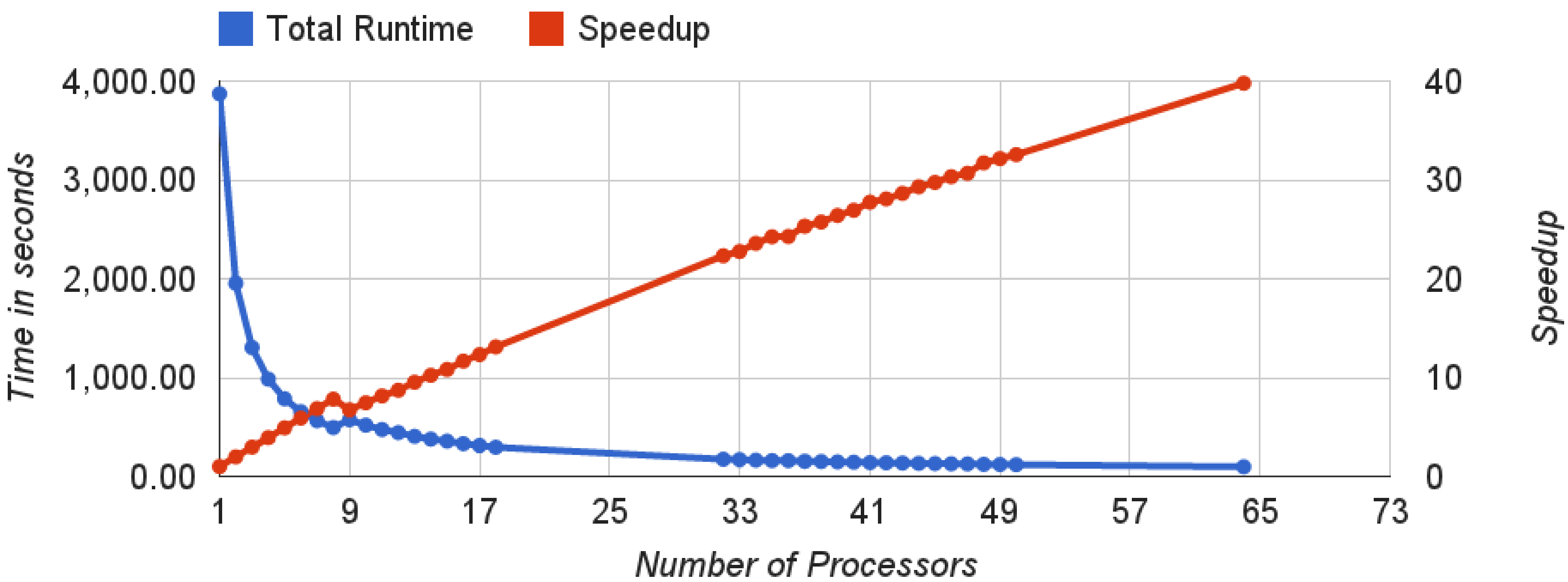


image source: autoanything

Benchmarks

Seventh Test: MPI on $2 \cdot 32$ Core Systems

- 2 hosts with 32 Xeon E7-4830 at 2.13GHz
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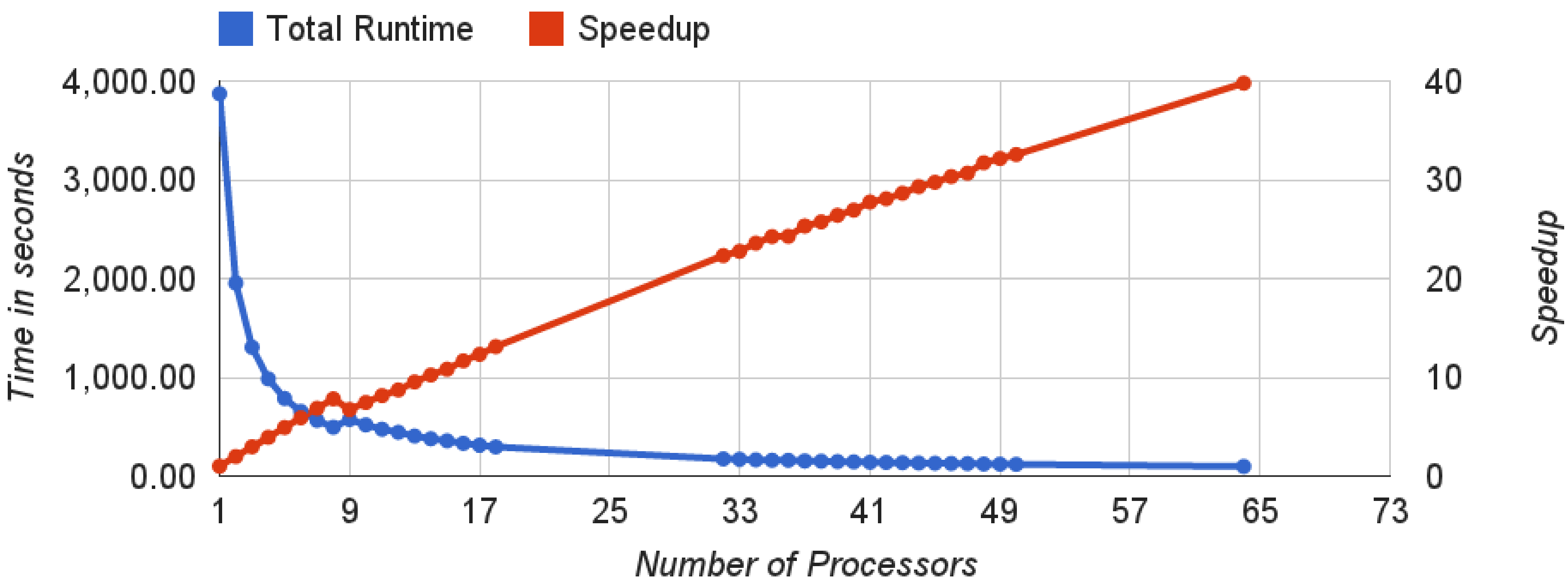


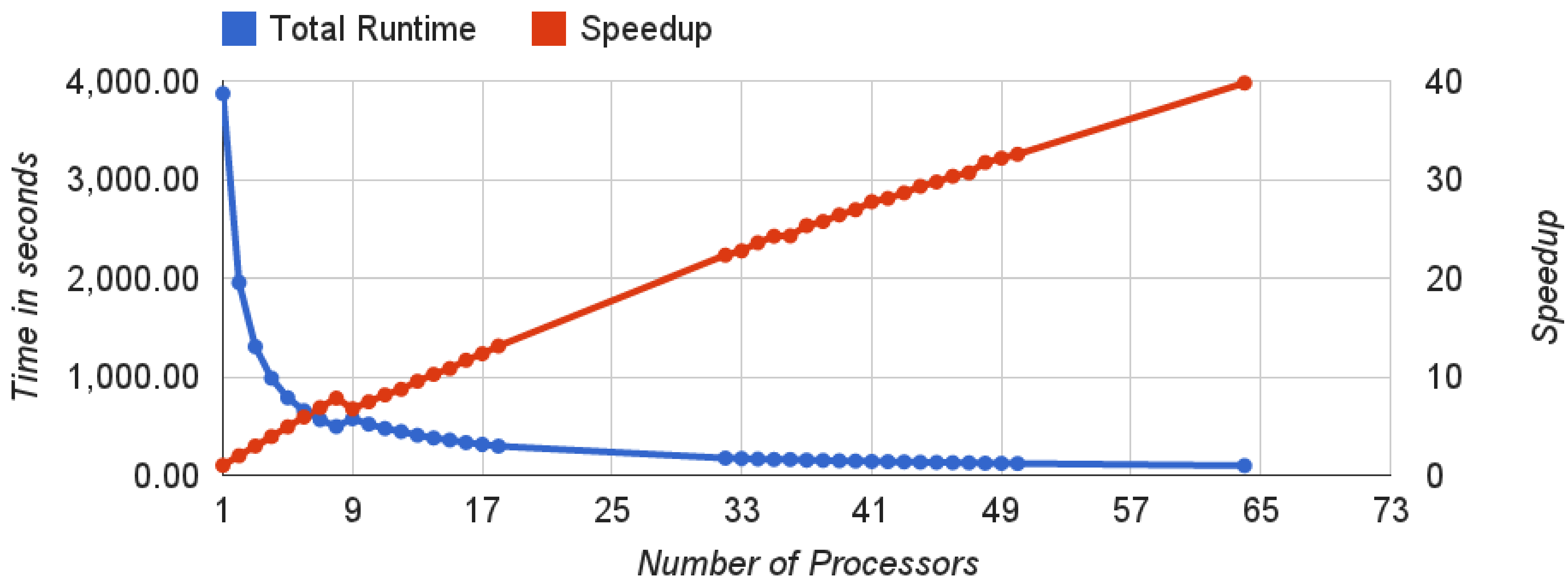
- 97.30 seconds to find collision

image source: autoanything

Benchmarks

Seventh Test: MPI on $2 \cdot 32$ Core Systems

- 2 hosts with 32 Xeon E7-4830 at 2.13GHz
- input: md5(x) with $x \in \{0,1\}^{32}$



- 97.30 seconds to find collision
- approx. 1 billion strings tried

image source: autoanything

Benchmarks

Seventh Test: MPI on $2 \cdot 32$ Core Systems

- 2 hosts with 32 Xeon E7-4830 at 2.13GHz
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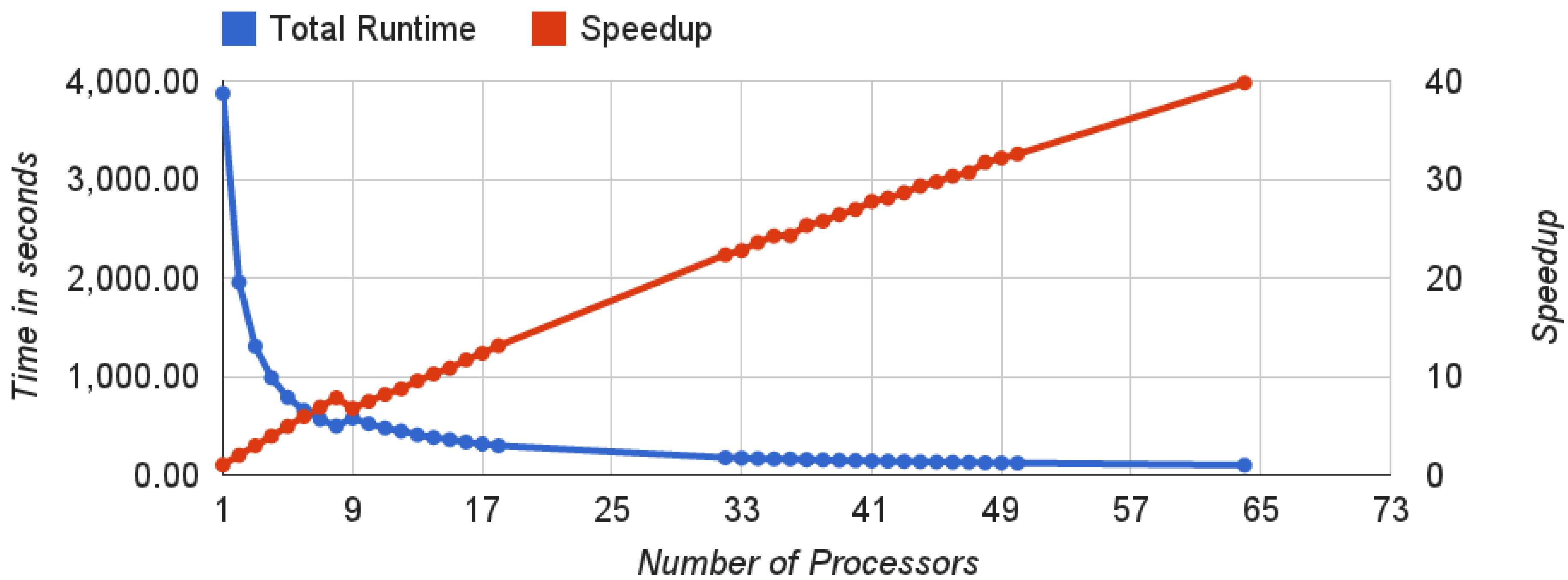

- 97.30 seconds to find collision
- approx. 1 billion strings tried

→ linear speedup

image source: autoanything

Explanations and Expectations

image source: ozbinoculars

Explanations and Expectations

OpenMP implementation

image source: ozbinoculars

Explanations and Expectations

OpenMP implementation

- linear speedup due to few communication

image source: ozbinoculars

Explanations and Expectations

OpenMP implementation

- linear speedup due to few communication
- suitable for smaller problem sizes

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Explanations and Expectations

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- linear speedup due to few communication
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  but: already used CCR's "biggest" machine

image source: ozbinoculars

Explanations and Expectations

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- linear speedup due to few communication
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MPI implementation

image source: ozbinoculars

Explanations and Expectations

OpenMP implementation

- linear speedup due to few communication
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MPI implementation

- slower communication, setup overhead

image source: ozbinoculars

Explanations and Expectations

OpenMP implementation

- linear speedup due to few communication
- suitable for smaller problem sizes

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MPI implementation

- slower communication, setup overhead
- more processors available

image source: ozbinoculars

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image source: ozbinoculars

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compare

image source: ozbinoculars

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compare $x \in \{0,1\}^{32}$

image source: ozbinoculars

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compare $x \in \{0,1\}^{32}$

OpenMP

MPI

image source: ozbinoculars

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- suitable for smaller problem sizes

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compare $x \in \{0,1\}^{32}$

# PEs	32
OpenMP	
MPI	

image source: ozbinoculars

Explanations and Expectations

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- linear speedup due to few communication
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- more processors available

  suitable for larger problem sizes

compare $x \in \{0,1\}^{32}$

# PEs	32
OpenMP	152s
MPI	174s

image source: ozbinoculars

Explanations and Expectations

OpenMP implementation

- linear speedup due to few communication
- suitable for smaller problem sizes

  but: already used CCR's "biggest" machine

MPI implementation

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- more processors available

  suitable for larger problem sizes

compare $x \in \{0,1\}^{32}$

# PEs	32	64
OpenMP	152s	
MPI	174s	

image source: ozbinoculars

Explanations and Expectations

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  but: already used CCR's "biggest" machine

MPI implementation

- slower communication, setup overhead
- more processors available

  suitable for larger problem sizes

compare $x \in \{0,1\}^{32}$

# PEs	32	64
OpenMP	152s	–
MPI	174s	97s

image source: ozbinoculars

Explanations and Expectations

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- linear speedup due to few communication
- suitable for smaller problem sizes

  but: already used CCR's "biggest" machine

MPI implementation

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  suitable for larger problem sizes

CUDA implementation

image source: ozbinoculars

Explanations and Expectations

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- linear speedup due to few communication
- suitable for smaller problem sizes

  but: already used CCR's "biggest" machine

MPI implementation

- slower communication, setup overhead
- more processors available

  suitable for larger problem sizes

CUDA implementation (future work)

image source: ozbinoculars

Explanations and Expectations

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- linear speedup due to few communication
- suitable for smaller problem sizes

  but: already used CCR's "biggest" machine

MPI implementation

- slower communication, setup overhead
- more processors available

  suitable for larger problem sizes

CUDA implementation (future work)

- fast communication between processing elements

image source: ozbinoculars

Explanations and Expectations

OpenMP implementation

- linear speedup due to few communication
- suitable for smaller problem sizes

but: already used CCR's "biggest" machine

MPI implementation

- slower communication, setup overhead
- more processors available

suitable for larger problem sizes

CUDA implementation (future work)

- fast communication between processing elements
- very high number of processors on single nodes

image source: ozbinoculars

Sources and References

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Alfred J. Menezes, Paul C. van Oorschot, Scott A. Vanstone. *Handbook of Applied Cryptography*. CRC Press, 1996.

Charles P. Pfleeger and Shari L. Pfleeger. *Analyzing Computer Security: A Threat/Vulnerability/Countermeasure Approach* Prentice Hall, 2011.