**Parallel Processing Paradox: A Comparison of Amdahl’s and Gustafson’s Laws**

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30 March 2018

# Introduction

Processing power has advanced exponentially in the last 25 years. What once required room-sized supercomputers are now computable on the personal mobile phone. Processing speed has advanced so far that creating smaller, faster processor beginning to become physically impossible.

So what can be done? If there is a physical limit to how fast we can make one processor, are we approaching the limits to computing? The answer is no. If we cannot make a faster processor, how about using two, three, or more processors at the same time? This answer is where Parallel Computing begins.

What is the benefit of this parallel processing. If we consider a program that is perfectly parallized, where all of the processing of the program is done in parallel, then we can reasonably conclude that we want an increase in speed proportional to that of the number of processors we add to the program. This excited people. Simply by adding processors, could we get linear (or even near linear) speedup of our software?

This paper will explore two seemingly conflicting responses to this question. Amdahl’s and Gustafson’s Laws. Both are mathematically sound but contradict each other. This paper will explore each of the laws and examines its answers to this question. Finally, the paper will examine whether each law truly answers the question at hand.

# Amdahl’s Law

In 1967, Gene Amdahl formulated the basis for what would be called Amdahl’s Law. While Amdahl did not give a specific formula in his paper, the literal description of the law gave rise to this law:

Where

* is the theoretical speedup of the execution of the whole tasks
* is the speedup of the part of the task that benefits from improved system resources
* is the proportion of the execution time that the part benefiting from improved resources originally occupied. [1]

Amdahl concluded that because of the extra hardware and connections required by two processors instead of one, compared to a processor twice as fast, “The net result (of two processors) is a price performance degradation to 0.8 rather than an improvement to 2.0 for the single larger processor.”

This is worrisome. If multiple processors do not increase the performance of a system, then we will eventually run into diminishing returns regarding performance. Indeed, Amdahl’s paper was a splash of cold water into the growing field of computer science.

# Gustafson’s Law

This pall that hung over the growing field of parallel computation lasted until 1985. That year, John L. Gustafson, working at Sandia National Laboratories, published a paper entitled *Reevaluating Amdahl’s Law*. This short paper described their research into massively-processing and addressed the skepticism surrounding it. Gustafson worked on a 1024-processor system and they performed timing tests on that system. Using Amdahl’s Law, as simplified speedup of the problem would be close to 1/1024, a value very close to 0.

However, Gustafson’s paper described 3 programs run on their 1024-processor machine that averaged a speedup of 1019 for the experiment described in his paper. It’s not quite 1024, but is nearly a 1:1 improvement.

# List of References

[1] <http://www-inst.eecs.berkeley.edu/~n252/paper/Amdahl.pdf>

[2] http://www.johngustafson.net/pubs/pub13/amdahl.htm