Amdahl’s Law

Amdahl's Law is a fundamental principle in parallel computing that relates to the theoretical speedup of a program when adding additional processing units. The law is named after Gene Amdahl, a computer architect and computer science pioneer.

Amdahl's Law states that the theoretical maximum speedup of a program is limited by the proportion of the program that cannot be parallelized. In other words, if a program has a sequential portion that cannot be executed in parallel, then adding more processors will not improve the overall performance of the program beyond a certain point.

The equation for Amdahl's Law is:

Speedup = 1 / (S + ((1 - S) / N))

Where:

S is the fraction of the program that can be parallelized.

N is the number of processors used.

This equation shows that the maximum speedup of a program is limited by the serial fraction (1-S) of the program. As the number of processors used (N) increases, the speedup of the program will improve, but only up to a certain point.

For example, if a program has a serial fraction of 10% (S=0.1), then the maximum theoretical speedup that can be achieved by adding additional processors is 9.09x for 10 processors, 16.67x for 100 processors, and so on. Amdahl's Law highlights the importance of identifying the portion of a program that cannot be parallelized and optimizing it for performance. It also emphasizes the importance of designing parallel algorithms and architectures that can minimize the serial fraction of a program to achieve better performance.

Handler’s Law

Hander's Law, also known as Gustafson-Barsis's Law, is a principle in parallel computing that provides an alternative to Amdahl's Law for estimating the speedup of a program when adding more processors. The law is named after John Gustafson and James Barsis, who first formulated the principle in 1988. Unlike Amdahl's Law, which assumes a fixed problem size, Hander's Law assumes that the problem size can be scaled up as more processors are added to the system. In other words, as the number of processors increases, so does the size of the problem that can be solved in the same amount of time.

The equation for Hander's Law is:

$$\textbf{Speedup} = (S + P) / S$$

Where:

S is the serial fraction of the program (i.e., the portion that cannot be parallelized).

P is the parallel fraction of the program (i.e., the portion that can be parallelized).

This equation shows that the maximum speedup of a program is determined by the parallel fraction of the program. As the number of processors used increases, the speedup of the program will improve, and the problem size that can be solved in the same amount of time will increase.

For example, if a program has a serial fraction of 10% (S=0.1) and a parallel fraction of 90% (P=0.9), then the maximum theoretical speedup that can be achieved by adding more processors is 10x for 1 processor, 20x for 10 processors, and so on.

Hander's Law highlights the importance of designing parallel algorithms and architectures that can scale to larger problem sizes as more processors are added. It also emphasizes the importance of optimizing the parallel fraction of a program to achieve better performance.