Amdahl's Law

Amdahl's Law focuses on the potential speedup of a task when parts of it can be parallelized. It states that the overall performance improvement of a system is limited by the portion of the task that cannot be parallelized. Essentially, even if most of a process can run concurrently, the sequential part becomes a bottleneck as you add more processors. This means that adding more processors will yield diminishing returns if a significant fraction of the task remains sequential. Therefore, Amdahl's Law emphasizes that optimizing the sequential portion is crucial to achieving higher speedups in parallel computing.

Gustafson's Law

Gustafson's Law offers a different perspective on parallel computing by focusing on scalability and the idea that larger problems can be tackled as more processors are added. It suggests that as we increase the number of processors, we can also proportionally increase the workload. This means that the parallel portion of the task becomes more significant, and the impact of the sequential part diminishes. Unlike Amdahl's Law, which assumes a fixed problem size, Gustafson's Law argues that the true benefit of parallel computing is realized when larger problems are solved efficiently, making the parallelization more practical and beneficial as the number of processors grows.

Calculating FFF and F′F'F′

To calculate FFF and F′F'F′, let's use the idea that they represent different aspects of parallel execution:

- **FFF in Amdahl's Law**: Represents the portion of the computation that is strictly sequential, limiting the maximum speedup regardless of the number of processors. As more processors are added, the sequential part FFF remains a bottleneck.
- **F′F'F′ in Gustafson's Law**: Represents the fraction of time spent on the sequential part when executing on a parallel system. Gustafson's Law assumes that the workload increases with the number of processors, allowing the parallel portion to dominate as more processors are added.

Relationship and difference between FFF and F′F'F′

- In **Amdahl's Law**, FFF is fixed and represents the inherent sequential nature of the problem. It emphasizes the limitation of adding more processors to a fixed problem size.
- In **Gustafson's Law**, F′F'F′ can change with problem size because the time spent on the parallelizable part grows with more processors. This law assumes that increasing the number of processors also scales up the workload, making the sequential part relatively smaller.

Why FFF and F′F'F′ are not the same

1. **Different Perspectives on Scaling**

   Amdahl's Law considers a fixed problem size, so FFF is the intrinsic sequential fraction that limits speedup. In contrast, Gustafson's Law scales the problem size with the number of processors, so F′F'F′ reflects how much of the runtime remains sequential relative to the expanding parallel work.

2. **Impact of Increasing Processors**

   In Amdahl's Law, increasing the number of processors doesn't change the fraction FFF, it only attempts to speed up the parallel portion. In Gustafson's Law, increasing the number of processors scales up the problem, which makes the sequential fraction F′F'F′ smaller relative to the total computation.