4.2 Parallel Processing Challenges

- The tall challenge facing the industry is to create hardware and software that will make it easy to write correct parallel processing programs that will execute efficiently in performance and energy as the number of cores per chip scales.
- It is difficult to write software that uses multiple processors to complete one task faster, and the problem gets worse as the number of processors increases.
- We must get better performance or better energy efficiency from a parallel processing program on a multiprocessor.
- It is difficult to write parallel processing programs that are fast, especially as the number of processors increases.
- For parallel programming, the challenges include scheduling, partitioning the task into parallel pieces, balancing the load evenly between the processors and so on.

Amdahl's Law

- Amdahl's law is used to calculate the performance gain that can be obtained by improving some portion of a computer. It states that the performance improvement to be gained from using some faster mode of execution is limited by the fraction of the time the faster mode can be used.

- **Speed up (Performance improvement) :** It tells us how much faster a task can be executed using the machine with the enhancement as compare to the original machine. It is defined as

$$\text{Speed up} = \frac{\text{Performance for entire task using improved machine}}{\text{Performance for entire task using old machine}}$$

$$\text{or Speed up} = \frac{\text{Execution time for entire task using improved machine}}{\text{Execution time for entire task using original machine}}$$

- **Fraction enhanced :** It is the fraction of the computation time in the original machine that can be converted to take advantage of the enhancement. For example, if CPU's I/O section is enhanced and it is assumed that CPU is busy 60 % of the time in I/O operations, then fraction enhanced = 0.6. Fraction enhanced is always less than or equal to 1.

- **Speed up $_{\text{enhanced}}$:** It tells how much faster the task would run if the enhancement mode was use for the entire program. For example, if CPU's I/O section is made 10 times faster than Speed up $_{\text{enhanced}}$ is 10. Speed up enhancement is always greater than 1.

- Amdahl's law gives us a quick way to find the speed up from two factors : fraction enhance (F_e) and speed up enhanced (S_e). It is given as

$$\text{Speed up} = \frac{\text{Execution time}_{\text{old}}}{\text{Execution time}_{\text{new}}} = \frac{E_{TO}}{E_{TN}}$$

where $$E_{TN} = E_{TO} \times \left[(1 - F_e) + \frac{F_e}{S_e}\right]$$

$$\therefore \text{Speed up} = \frac{E_{TO}}{E_{TO} \times \left[(1 - F_e) + \frac{F_e}{S_e}\right]}$$

$$= \frac{1}{(1 - F_e) + \frac{F_e}{S_e}}$$

Example 4.2.1 *What percentage of the original computation can be sequential to achieve a speedup of 80 times faster with 100 processors ?*

Solution : Given : Speed up = 80, Speed enhanced = S_e = 100, F_e = ?

We have, $$\text{Speedup} = \frac{1}{(1 - F_e) + \frac{F_e}{S_e}}$$