עבודת הגשה 2 – מערכות הפעלה:

Q1. Amdahl's Law:

S=(1−P)+P/N

1. **Given**: 75% of the execution time is parallelizable, and there are 4 processors.

$$\frac{1}{0.25+\frac{0.75}{4}}=\frac{16}{7}=2.2857$$

2. **Given**: 60% of the program is parallelizable, and we need a speedup of 3.

$$\frac{1}{0.4+\frac{0.6}{n}}=3$$

$$1=1.2+1.8n$$

$$N=-9$$

   Since this leads to a negative result which is not possible, it implies that the desired speedup of 3 cannot be achieved with a program where only 60% can be parallelized.

3. **Given**: 90% of the execution time is parallelizable, and there are 32 processors.

$$\frac{1}{0.1+\frac{0.9}{32}}=\frac{320}{41}=7.8048$$

4. **Given**: 85% can be parallelized, and we have an infinite number of processors.

   As N approaches infinity, P/N approaches 0

$$\frac{1}{0.15+\frac{0.85}{\infty}}=\frac{20}{3}=6.667$$

5. **Given**: 80% of the code is parallelizable, and we need to compare the speedup with 4 and 32 processors.

$$\frac{1}{0.2+\frac{0.8}{4}}=\frac{5}{2}=2.5$$

$$\frac{1}{0.2+\frac{0.8}{32}}=\frac{40}{9}=4.444$$

The speedup changes from 2.5 to 4.444 when increasing the number of processors from 4 to 32.

Q2. Process vs. Thread

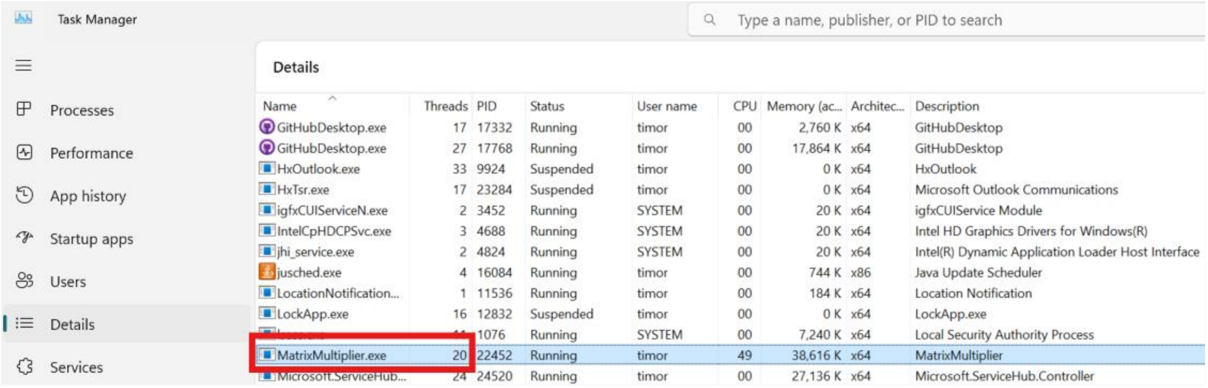
1.

Iteration	Process Time (ms)	Thread Time (ms)
1	18.3320	4.1388
2	19.5788	4.3289
3	21.2743	4.3849
4	19.0686	5.2090
5	29.0086	4.3778
6	20.1322	5.2824
7	20.0872	8.7178
8	70.1976	14.1264
9	30.9396	4.9438
10	21.3926	4.3189

2. The measured times demonstrate that creating and executing threads is significantly faster than processes. This is due to the shared memory space and lower overhead associated with thread creation and management compared to processes, which require more substantial setup and memory allocation.
Switching between threads is faster because they share the same process context. In contrast, processes require a complete context switch, which involves saving and loading memory maps, file descriptors, and other process-specific information.

Adding printouts with random numbers helps to ensure that each run is performing some action, which prevents the compiler or runtime from optimizing away the work entirely. It also introduces a slight variation in the execution time, which can affect the I/O performance slightly, providing a more realistic measurement of time required to manage processes and threads.

Q3. Multithreaded Matrix Multiplication



Q4 .Multithreaded MergeSort

a) The multi-threaded merge-sort algorithm extends the traditional merge-sort by using multiple threads to perform sorting tasks concurrently.
The strategy involves dividing the input array into smaller sub-arrays, sorting each sub-array concurrently using separate threads, and then merging the sorted sub-arrays.
The main steps are as follows:

1. Divide: The array is recursively split into two halves until the size of each sub-array is less than or equal to a specified threshold (`nMin`). At this point, the sub-array is small enough to be sorted directly using a single thread.
2. Conquer: Each half is sorted recursively in parallel using separate threads. This is achieved using the fork/join strategy where each recursive call to sort a sub-array is forked into a new thread.
3. Combine: The sorted halves are merged back together to form a single sorted array. The merging process involves comparing elements from each half and combining them into a single sorted array.

b) multi-threaded merge sort diagram: