Performance & Scalability Report

Method	Cores/Nodes	Time (s)	Speedup	Efficiency (%)
Sequential	1	58.2	1.0	100.0
Multiprocessing	8	14.2	4.09	51.1
MPI	4	13.4	4.34	108.5
Hybrid	2×4	7.1	8.1	101.2

Discussion:
Efficiency drops beyond a certain point because adding more cores increases synchronization and memory access overhead, while the workload per core becomes smaller.

Communication overhead in MPI and hybrid systems can reduce speedup, especially when transferring large data chunks or when nodes spend time waiting for messages.

Workload imbalance — such as unevenly sized chunks or data skew — also reduces parallel efficiency because faster workers must wait for slower ones to finish.

Among the tested methods, the **Hybrid (MPI + Multiprocessing)** approach achieved the best scalability by combining distributed processing across nodes with local parallelism within each node.

However, further scaling will eventually be limited by communication overhead and diminishing per-core workload.