German Razo
CSCI551

Matrix Multiplication ijk Forms with MPI

Form ijk

Description of the data and task partitioning used, and why you chose it:

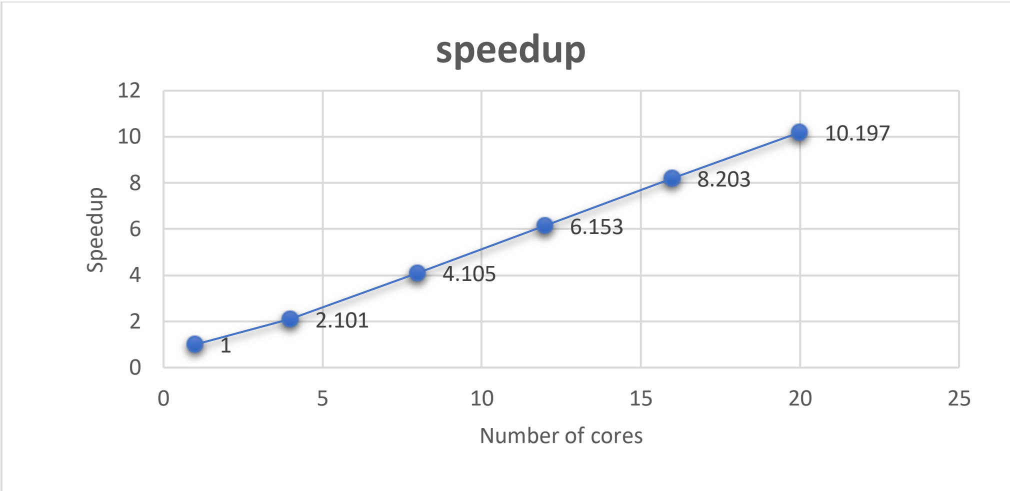
Every row in matrix A is divided and sent to different processes. Scatterv is utilized to have a balanced partitioning between processes, so no process gets more work than other processes. The approached that I used to have a balanced partitioning was to take the reminder of the division of the size of the processes and the size of the matrix, and if the reminder is greater than 0 it means that the result is odd otherwise is even and all processes get even rows, so if the result is odd from the reminder I add one more row from the matrix to process 0 and the rest of the reminder I add it to the next processors. For example, if the size of the matrix is 7 and there are 4 processes, the reminder from 7 % 4 is 3, so then I divide 7 / 4 which is 1, so all processes get 1 row, then since reminder is 3 I add 1 row to process 0 and process 2 and 3 gets one more row, so processes 1, 2 and 3 get 2 rows and process 3 gets 1 row, for a total of 7 rows, so this way data and task partitioning is balanced. In addition to this partitioning a variable called **sum** is used to take advantage of temporal locality because it is reference many times in the loop instead of using [i * n + j], which would be inefficient and cache would be wasted. I chose this partitioning because it gave good performance an accomplished great partitioning among cores. Array B is broadcasted to all processes.

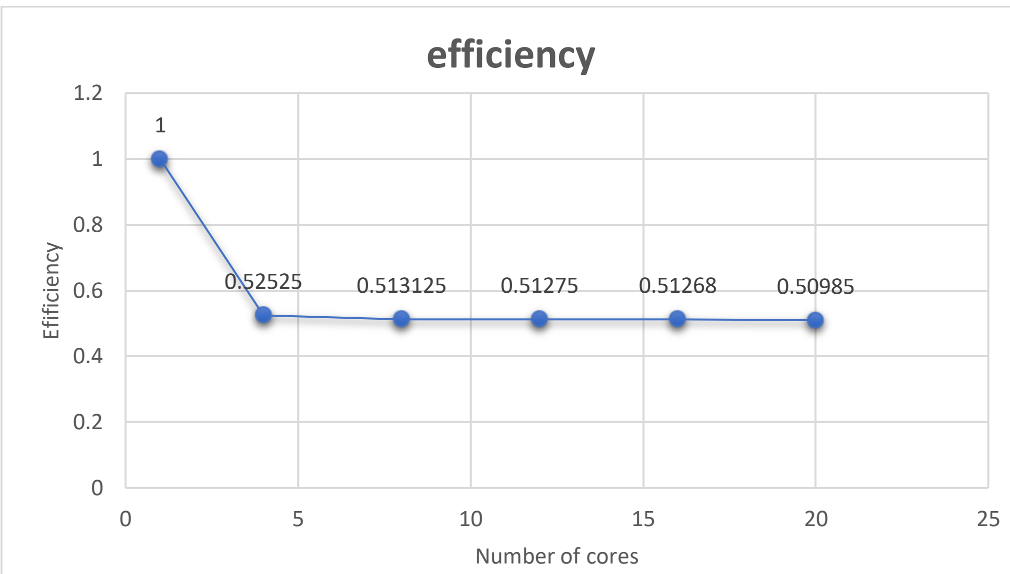
Table of timings

	Runs		
	1	**2**	**3**
comm_sz (number of cores)	Time(s)		
1	1697.315	1695.651	1699.666
4	806.7305	816.7302	813.6958
8	413.0692	414.5923	427.9018
12	292.7824	280.5531	275.5762
16	216.4538	206.6878	218.5750
20	176.9553	176.1812	166.2818

Speedup and efficiency

Number of cores	**Time(s)**	**Speedup**	**Efficiency**
1	1695.651	1	1
4	806.7305	2.101	.52525
8	413.0692	4.105	.513125
12	275.5762	6.153	.51275
16	206.6878	8.203	.51268
20	166.2818	10.197	.50985





Form ikj

Description of the data and task partitioning used, and why you chose it:

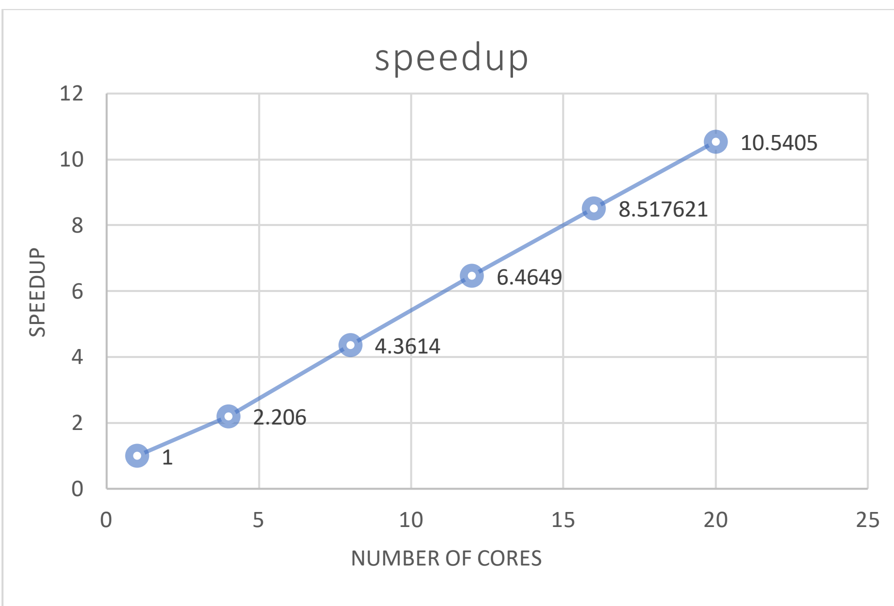
Every row in matrix A is divided and sent to different processes. Scatterv is utilized to have a balanced partitioning between processes, so no process gets more work than other processes. The approached that I used to have a balanced partitioning was to take the reminder of the division of the size of the processes and the size of the matrix, and if the reminder is greater than 0 it means that the result is odd otherwise is even and all processes get even rows, so if the result is odd from the reminder I add one more row from the matrix to process 0 and the rest of the reminder I add it to the next processors. For example, if the size of the matrix is 7 and there are 4 processes, the reminder from 7 % 4 is 3, so then I divide 7 / 4 which is 1, so all processes get 1 row, then since reminder is 3 I add 1 row to process 0 and process 2 and 3 gets one more row, so processes 1, 2 and 3 get 2 rows and process 3 gets 1 row, for a total of 7 rows, so this way data and task partitioning is balanced. In addition to this partitioning a variable called mid is used to take advantage of temporal locality because it is reference many times in the loop instead of using [(i * n) + k], which would be inefficient and cache would be wasted. I chose this partitioning because it gave good performance an accomplished great partitioning among cores Array B is broadcasted to all processes.

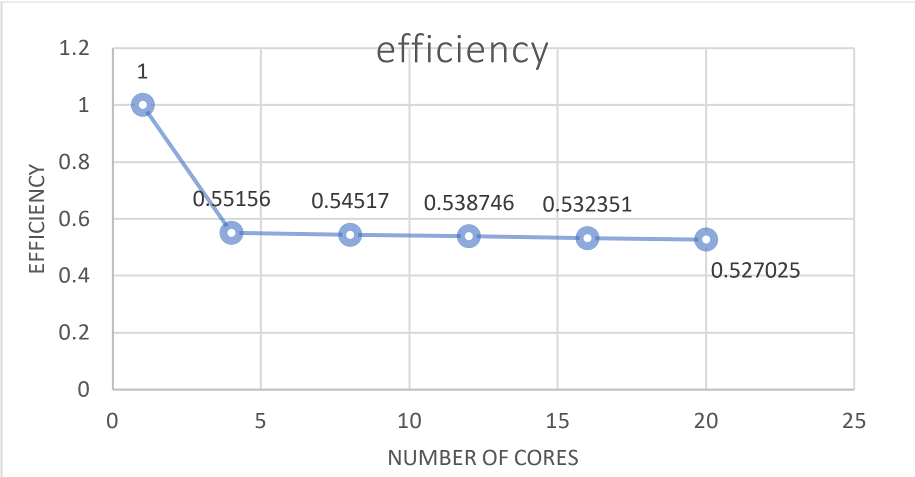
Table of timings

	Runs		
	1	**2**	**3**
comm_sz (number of cores)	Time(s)		
1	864.4907	864.3214	865.2361
4	392.2419	391.7590	392.3145
8	198.3915	198.1765	198.6629
12	133.6930	133.7139	134.0961
16	101.4745	101.5999	101.6746
20	82.23055	82.22957	82.15704

Speedup and Efficiency

Number of cores	Time(s)	Speedup	Efficiency
1	864.3214	1	1
4	391.7590	2.206	.55156
8	198.1765	4.3614	.54517
12	133.6930	6.4649	.538746
16	101.4745	8.517621	.532351
20	82.15704	10.5405	.527025



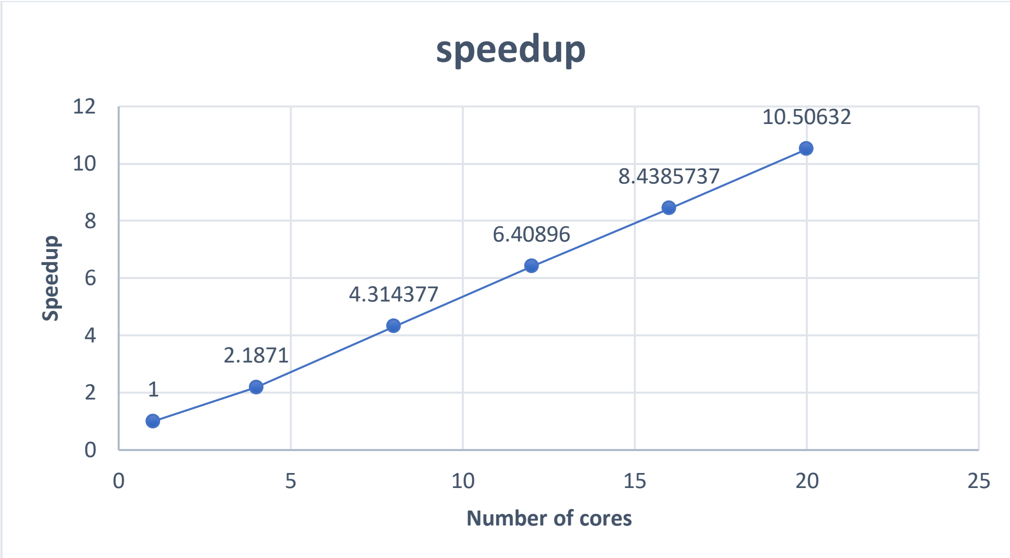


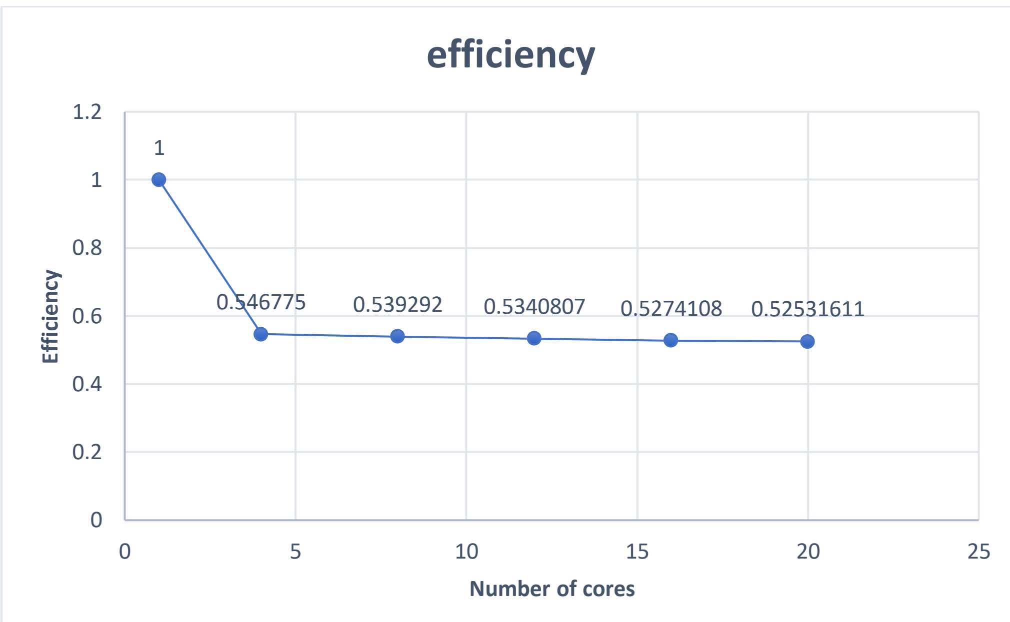
Form kij
Description of the data and task partitioning used, and why you chose it:
Every row in matrix A is divided and sent to different processes. Scatterv is utilized to have a balanced partitioning between processes, so no process gets more work than other processes. The approached that I used to have a balanced partitioning was to take the reminder of the division of the size of the processes and the size of the matrix, and if the reminder is greater than 0 it means that the result is odd otherwise is even and all processes get even rows, so if the result is odd from the reminder I add one more row from the matrix to process 0 and the rest of the reminder I add it to the next processors. For example, if the size of the matrix is 7 and there are 4 processes, the reminder from 7 % 4 is 3, so then I divide 7 / 4 which is 1, so all processes get 1 row, then since reminder is 3 I add 1 row to process 0 and process 2 and 3 gets one more row, so processes 1, 2 and 3 get 2 rows and process 3 gets 1 row, for a total of 7 rows, so this way data and task partitioning is balanced. In addition to this partitioning a variable called mid is used to take advantage of temporal locality because it is reference many times in the loop instead of using [i * n + k], which would be inefficient and cache would be wasted. I chose this partitioning because it gave good performance an accomplished great partitioning among cores. Array B is broadcasted to all processes.

Table of timings

	Runs		
	1	**2**	**3**
comm_sz (number of cores)			
1	868.0398	868.1970	869.8750
4	397.0423	396.8905	396.7150
8	201.2338	201.2615	201.197
12	135.9288	135.5242	135.4414
16	103.3170	102.8657	103.2467
20	82.62071	83.38978	83.35589

Number of cores	**Time(s)**	**Speedup**	**Efficiency**
1	868.0398	1	1
4	396.8905	2.18710	.546775
8	201.197	4.314377	.539292
12	135.4414	6.40896	.5340807
16	102.8657	8.4385737	.5274108
20	82.62071	10.50632	.52531611





Observations, analysis, & conclusions

Thinking about how I would partition the task and data to every process was a difficult part and I put a lot of thought into to it, so every process gets balanced amount of work. I used the same partitioning for all the ijk forms, but of course the multiplication is different for all the forms, the only thing that have in common is the petitioned of work as I mentioned. Another important part of my code was to minimize the timing and I accomplished this by utilizing variables that would be referenced many times, for example as I mentioned instead of using [i * n + k] many times I used a variable instead and this improved performance, so for the form **kij** by utilizing a variable **mid,** time for 60 cores went from 100 seconds to 82 seconds, which was a huge performance, so this was a good improvement in my program. As observed in the graphs speedup and efficiency resulted in good performance, cores from 1 to 60 maintain an efficiency of 50% and speedup was half the number of processors, which is good performance. Also, the graphs showed that speedup increases with more cores and efficiency decreases with less cores.