Approximate Pattern Matching

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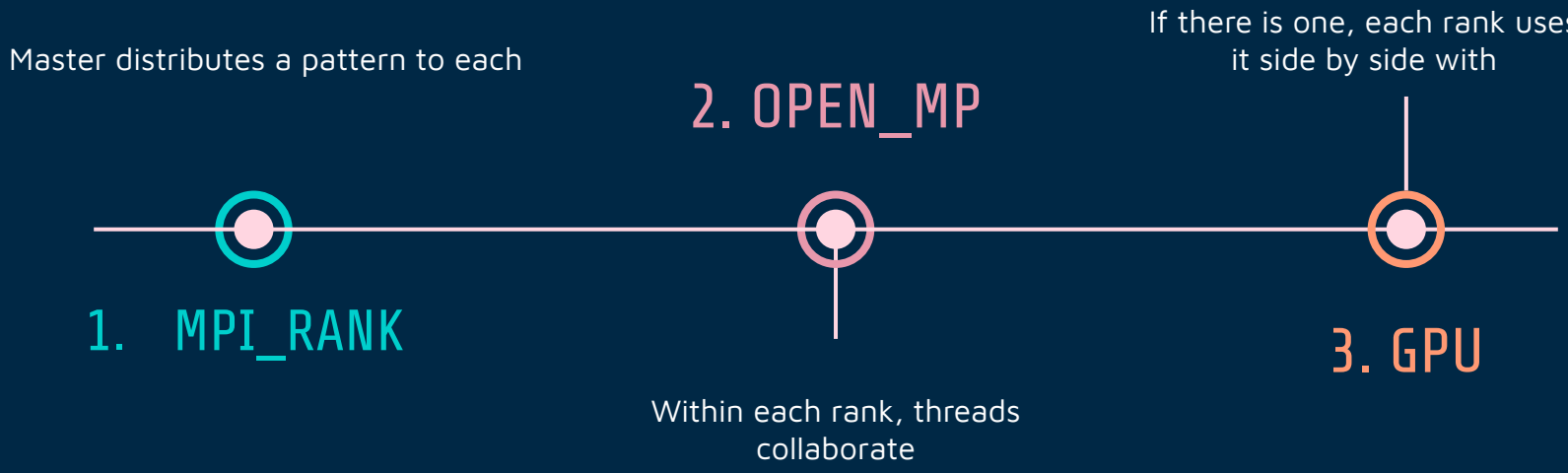
Parallelization Strategies

Patterns Over Ranks

Levels of parallelization



Database Over Ranks

2

Levels of parallelization

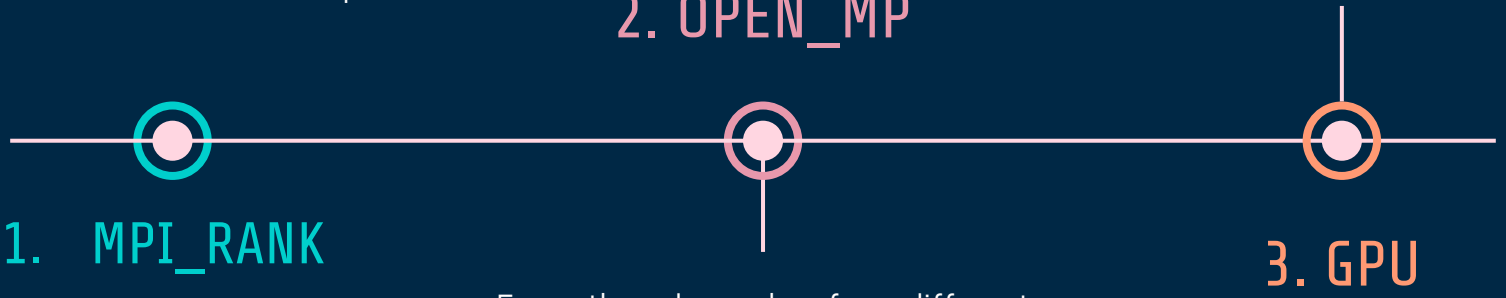
Rank 0

Assigns a piece of database to each rank. For every pattern waits the answers of ranks.

Other Ranks

Reads the piece of database and calculates the number of matches for each pattern.

If a GPU exists and the number of patterns is greater than one, the GPU will be used to further parallelize the searching of different patterns.



Every thread searches for a different pattern in the piece of the database.

Cost Model

1 Pattern

Advantages & Disadvantages

Thread loss concept

Patterns Over Ranks	- Only 1 MPI Rank is exploited - All Open MP threads exploited	(Active MPI Ranks−1) * OMP_Threads
Database Over Ranks	- Only 1 Open MP thread is exploited - All MPI Ranks exploited	Active MPI Ranks * (OMP_Threads - 1)

Multiple Patterns

Patterns over ranks

If the number of patterns is equal to the actual MPI ranks,
there is no round-robin.
All the hardware is being used. Every MPI rank has a pattern.
All the ranks will finish at the same time, after one iteration.

If the number of patterns is greater than the actual,
MPI ranks round robin takes place.
If the execution time of an iteration of round-robin is a divider
of the time slice, all the hardware is being used.
Otherwise, the use of the hardware is not optimized.

If the number of patterns is less than the actual MPI ranks,
some MPI ranks are not used.
The use of the hardware is not optimized.

Database over ranks

If the number of patterns is equal to the number of threads,
there is no round-robin.
All the hardware is being used.

If the number of patterns is greater than the number of threads, there is round-robin.
If the execution time of an iteration is a divider of the time slice, all the hardware is being used.
Otherwise, the use of hardware is not optimized.

If the number of patterns is smaller than the threads,
some threads are not used.
The use of the hardware is not optimized.

dimensionOfIterationPatternsOverRanks = ActiveMPIRanks/patterns
dimensionOfIterationDatabaseOverRanks = ThreadsPerRank/patterns

To calculate HardwareOptimizationPatternsOverRanks and HardwareOptimizationDatabaseOverPatterns:

```
while(x < 1){
x = x * 2
}
ratioHardwareOptimizationApproachChosen = x - 1;

if(ratioPatterns == 0 && ratioDatabase == 0){
        // Both of the approaches use the hardware at its maximum
        capacity. We could choose the approach randomly or in a
        predetermined way (as we did in the code).

} else{
        // Otherwise, we calculate the minimum between ratioPattern and
        ratioDatabase and we choose the approach which optimizes better
        the use of the hardware.
}
```

Experiment Results

Example 1. Let's assume we have 4 MPIranks, 3 threads, 6 patterns and a database with 100 characters.

$$dimensionOfIterationPatterns = ActiveMPIRanks/patterns = 4/6 = 0.6$$

$$dimensionOfIterationDatabase = ThreadsPerRank/patterns = 3/6 = 0.5$$

$$ratioPatterns = 0.2$$

$$ratioDatabase = 0$$

Execution time of Patterns over Ranks: 54 seconds
Execution time of Database over Ranks: 41 seconds

Example 2. Let's assume we have 4 MPIranks, 5 threads, 6 patterns and a database with 100 characters.

$$dimensionOfIteratioPatterns = ActiveMPIRanks/patterns = 4/6 = 0.6$$

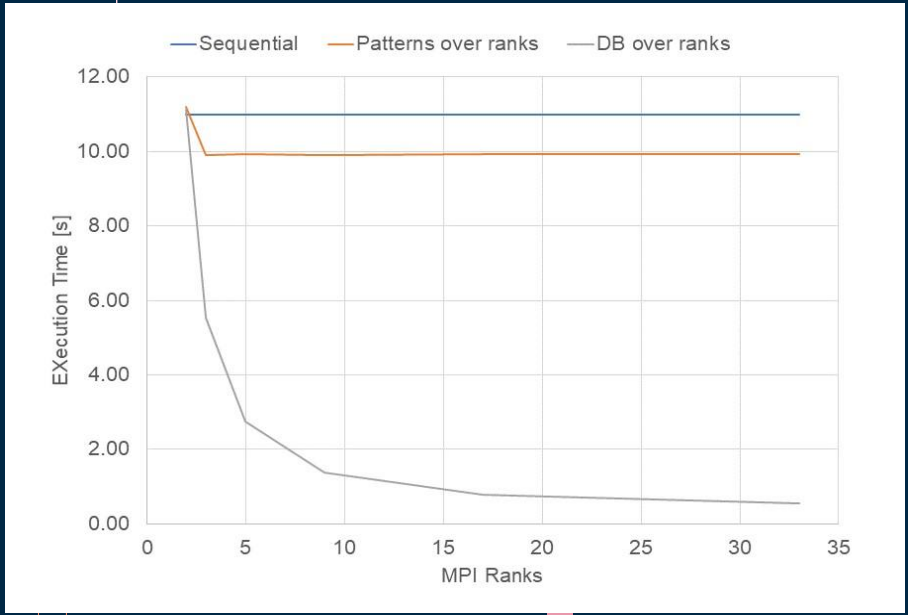
$$dimensionOfIterationDatabase = ThreadsPerRank/patterns = 5/6 = 0.8$$

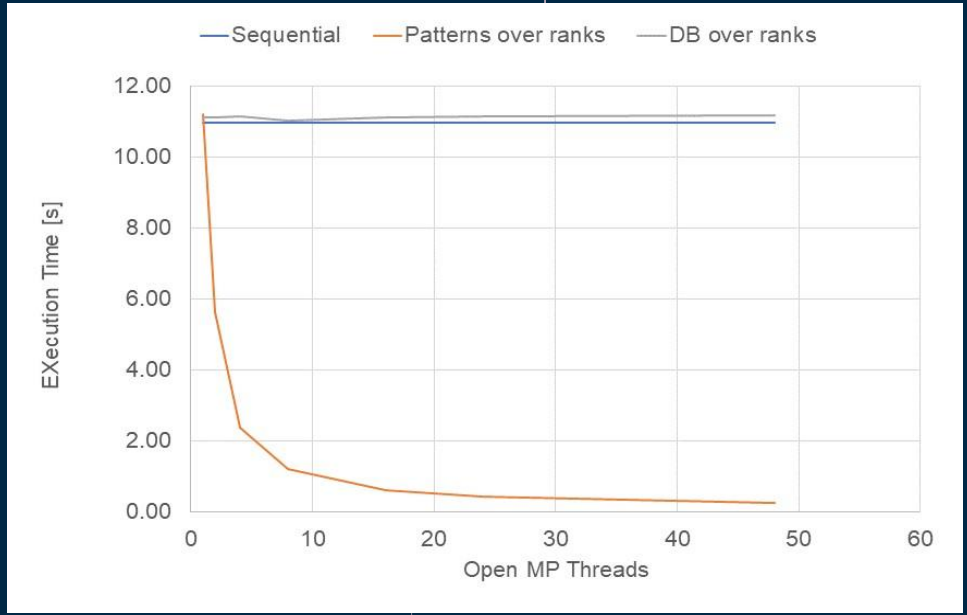
$$ratioPatterns = 0.2$$

$$ratioDatabase = 0.6$$

Execution time of Patterns over Ranks: 30.42 seconds
Execution time of Database over Ranks: 43.24 seconds

Strategies scaling: 1 pattern

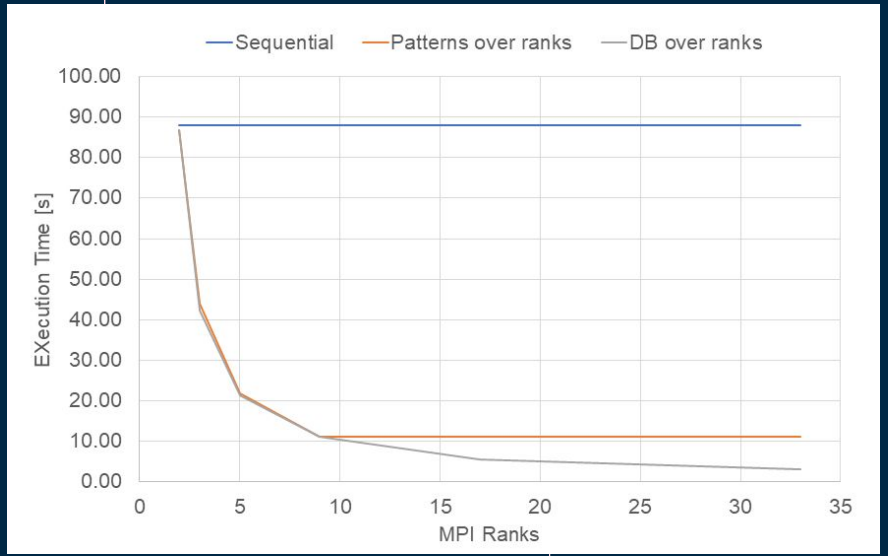


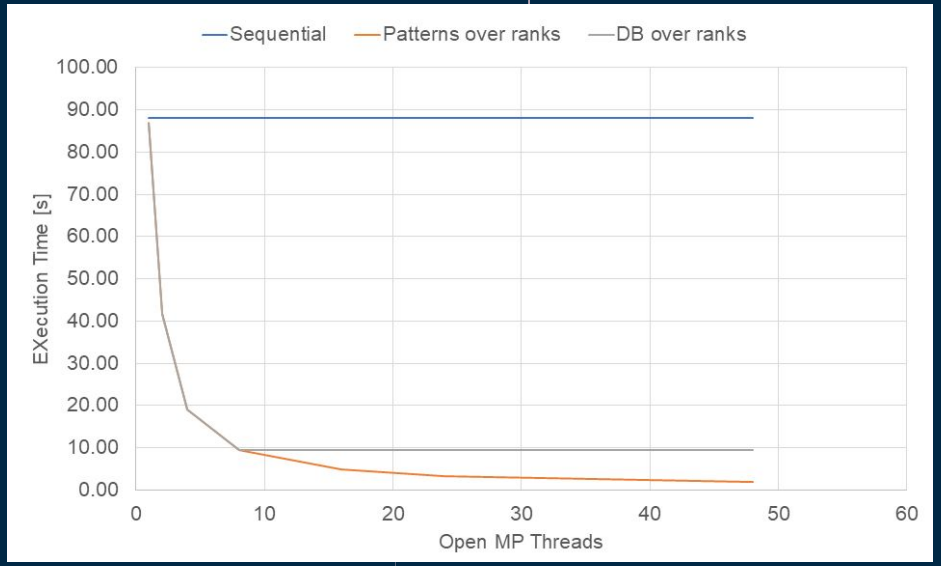


Database over ranks:
scales with ranks

Patterns over ranks:
scales with threads

Strategies scaling: multiple patterns





Database over ranks:
scales with ranks

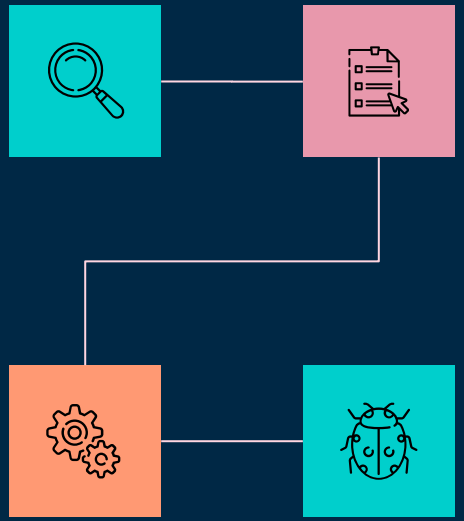
Patterns over ranks:
scales with threads

Notes

Notes

Performance Reading Database

Timer after all the ranks received patterns and buffer.



Assumptions

Program executed by 2 Ranks
No Multiple GPUs

Bug OpenMP Threads

We don’t see the results expected. Wwe added a special flag TESTPERFORMANCENOLEVENSHTEIN

Problem with sleep in CUDA

Bug Database Over Ranks

Sometimes happens that the approach DatabaseOverRanks see more matches than the real ones.

Thank you
for your attention