Exploiting System Level Heterogeneity to improve the performance of a GeoStatistics Multi-phase Task-based Application

50th International Conference on Parallel Processing

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Heterogeneity in HPC – At System-Level

System-Level Heterogeneity: Nodes with Different Computational Power

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Santos Dummont

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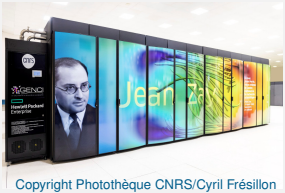
Four Partitions/Systems:

- GPU: Xeon 2695 + K40
- Hybrid: Xeon 2695 + Xeon Phi
- CPU: Xeon 2695
- SDumont: Xeon 6252 + V100

Jean Zay



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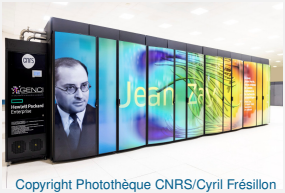

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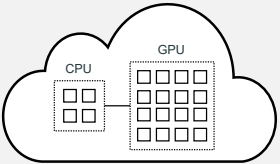

Many Different Instances

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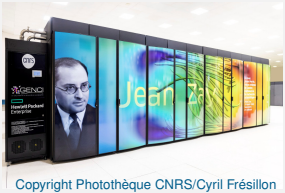

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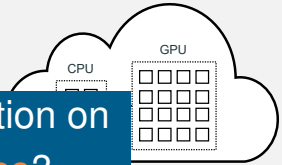
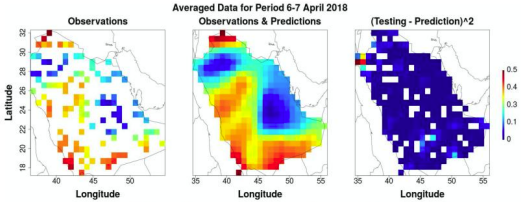


rent Instances

How to distribute an HPC application on these heterogeneous resources?

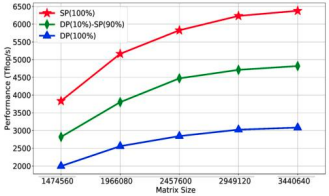
ExaGeoStat – Geostatistics on Manycore Systems

- Design at Kaust (Hatem Ltaief et al., 2018)
- Predict missing observations in climate/weather forecasting applications
- A Task-Based Application that uses Chameleon and StarPU
- Efficiency with Mixed-Precision shown with 4096 nodes



Prediction Accuracy using Space-Time model

Source: https://github.com/ecrc/exageostat



4096 **Shaheen-II** Cray XC40 Nodes

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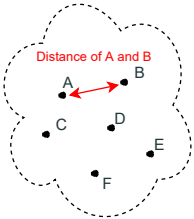
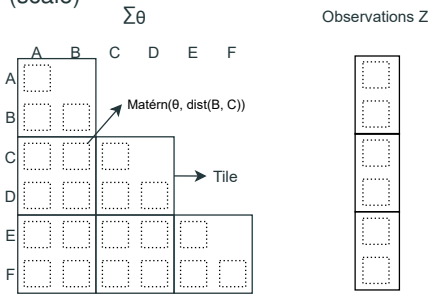
ExaGeoStat – Fits the Gaussian Process

Their Gaussian Process uses:

- Matérn function, hyper-parameter θ (scale)



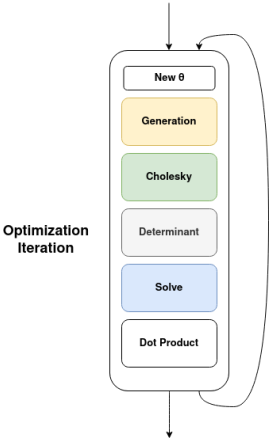


- Optimize θ to maximize Gaussian log-likelihood function:

$$l(\theta) = -\frac{n}{2}\log(2\pi) - \frac{1}{2}\log|\Sigma_\theta| - \frac{1}{2}Z^T\Sigma_\theta^{-1}Z$$

ExaGeoStat – Application DAG Structure

Multiple Phases



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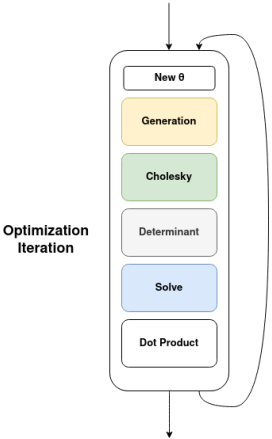
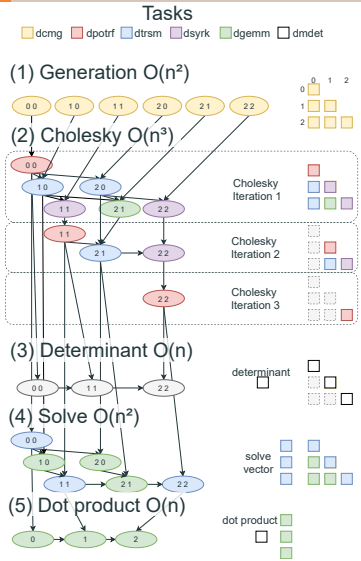
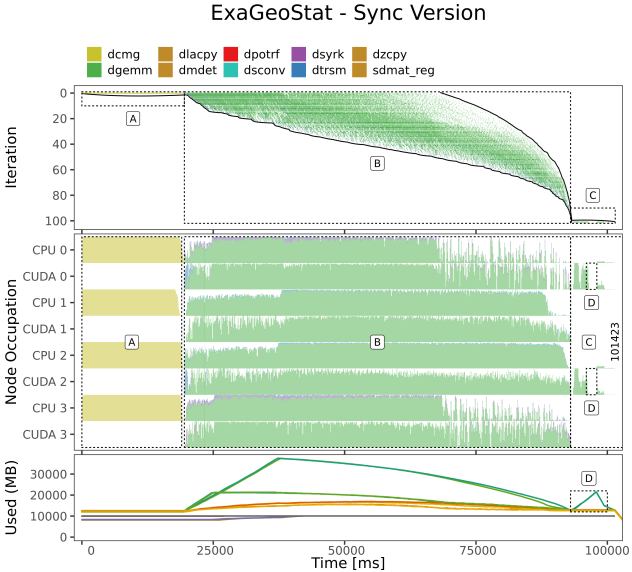




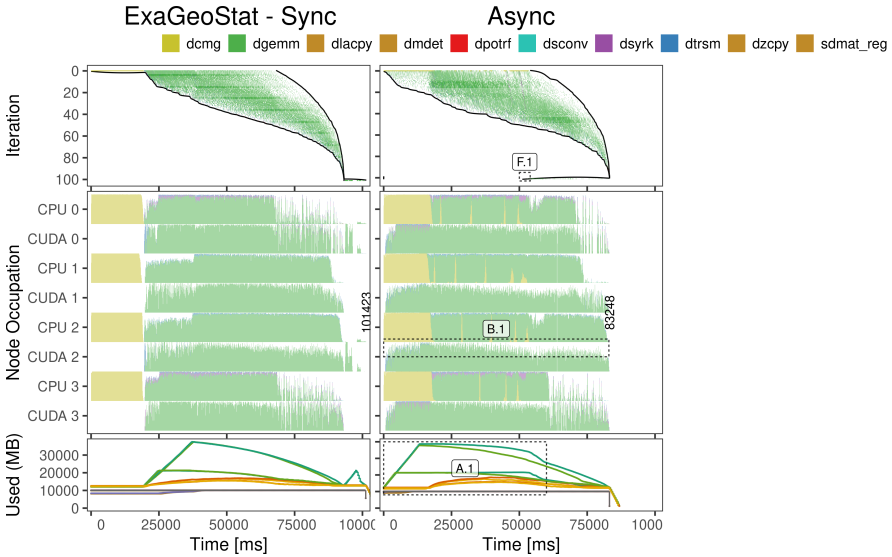
ExaGeoStat - Synchronous Version

Three Major phases

- A: Generation – Matérn
- B: Cholesky
- C: Solve, Determinant, Dot Product



Asynchronization Optimizations Results



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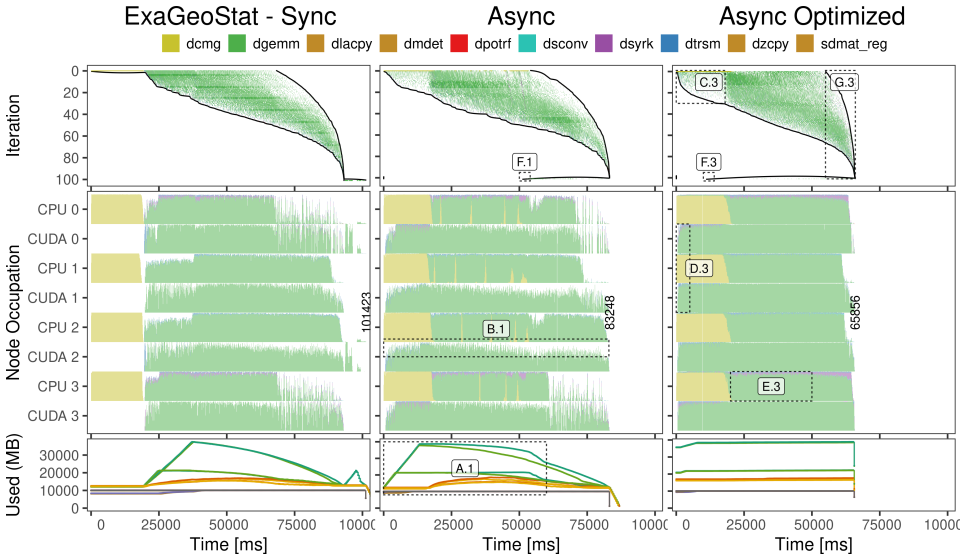

Computing Power for Multi-Phase Balancing

Notation

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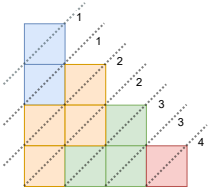

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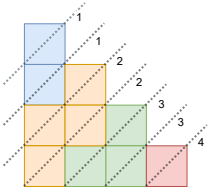

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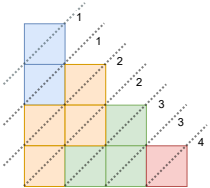

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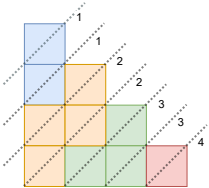

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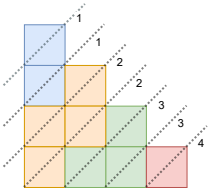

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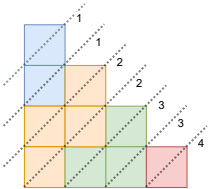

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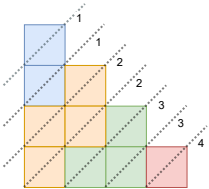

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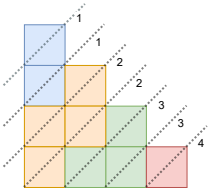
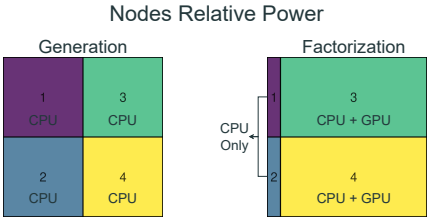
$$\min_{r \in \mathcal{R}} (w_{\text{dcmg},r}) \leq G_1$$



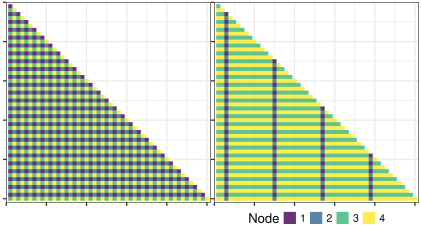
Multi Distributions: Communication Issue



Multi Distributions: Communication Issue

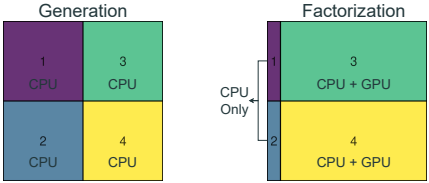
Block-Cyclic independent Generation distribution

1D-1D Factorization distribution



Total Communication Phases: 890

Nodes Relative Power



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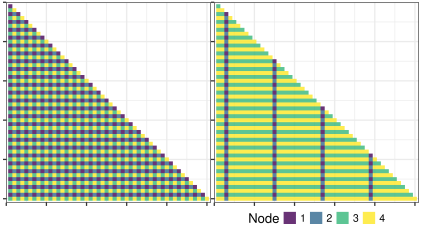
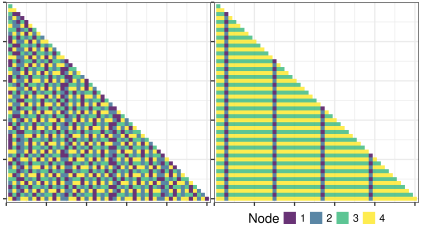


Total Communication Phases: 890

Improved Generation distribution

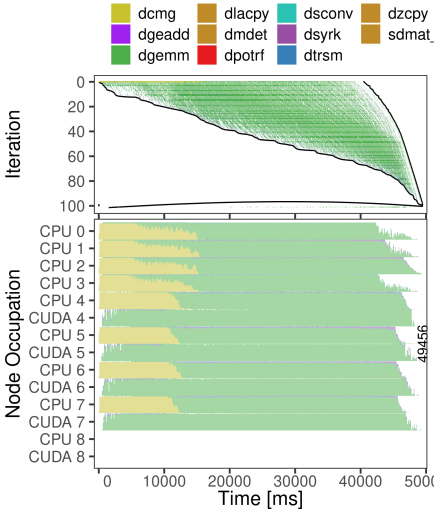
1D-1D Factorization distribution



Total Communication Phases: 517 (-41.9%)

Performance Evaluation

4 Chetemi + 4 Chifflet



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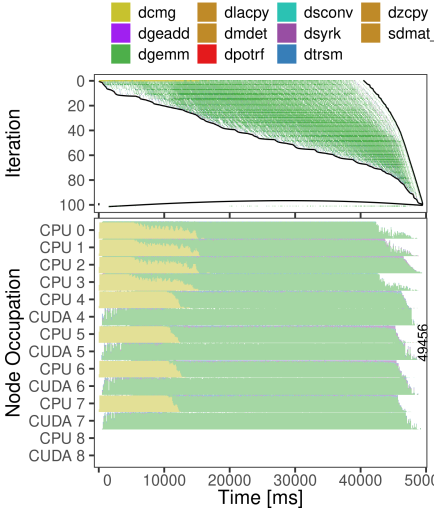

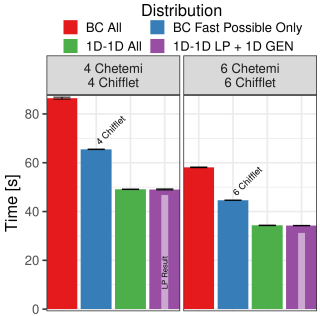

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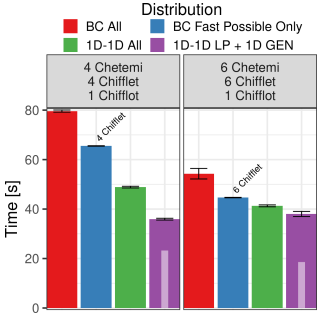

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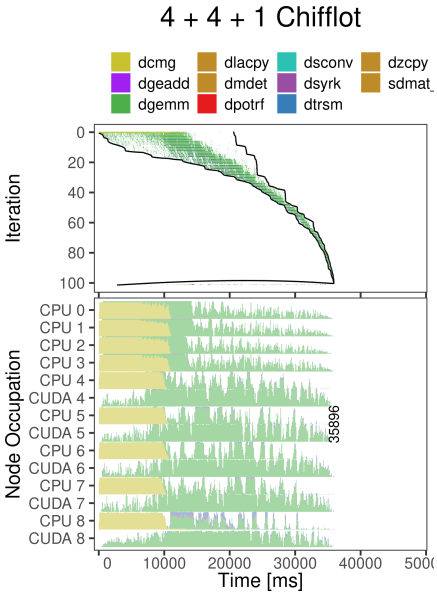
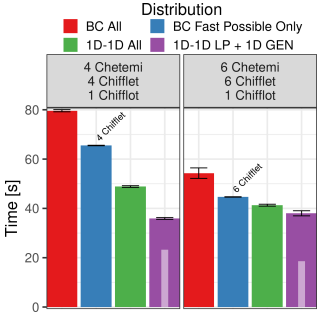
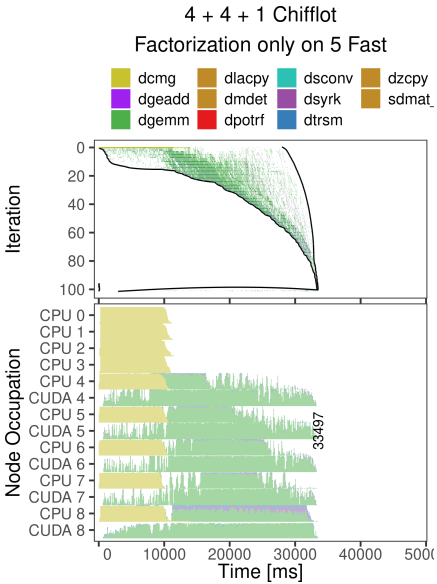
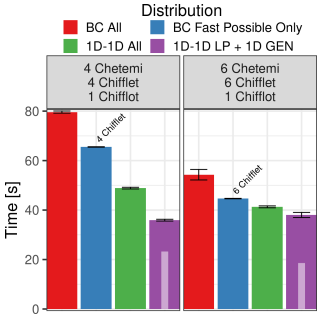




Performance Evaluation





Conclusion

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- Asynchronous Phase Execution with correct Overlapping
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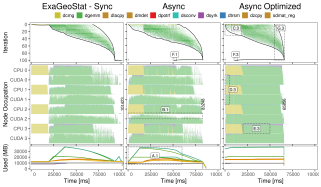

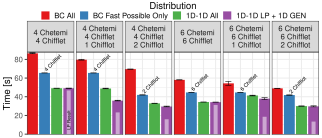

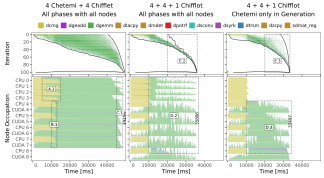

Conclusion

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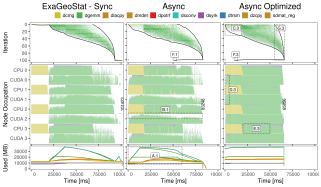
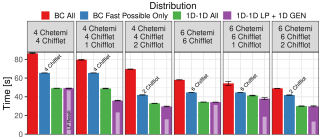
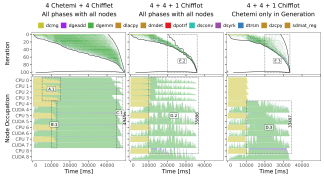
Correctaly using Node Heterogeneity improves performance







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Thank you!

Questions?

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